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Regina Hydraulic Study

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REGINA HYDRAULIC STUDY

Report No.

HYD-5-57

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SYNOPSIS

Flooding along the Wascana Creek through Regina, Saskatchewan has periodically been a problem. Major damage was sustained during the floods of 1911, 1925, 1956 and 1971. Minor flooding has occurred in a number of other years as well. A hydraulic study of flood flows on Wascana Creek through Regina, Pilot Butte Creek, Chuka Creek, and the North and South Storm Channels was undertaken under the Canada-Saskatchewan Flood Damage Reduction Program and is described in this report. Two zones were delineated in the flood hazard area, namely the floodway and floodway fringe. The results are presented in the form of water surface profiles and flood hazard maps. The 1:2000 scale flood hazard maps which show the historic and design floodlines as well as the two zone delineation are separate from this report, and are kept by the Land Protection Branch of Saskatchewan Environment.

The HEC II computer program was used to model the 1:100 year flood and the 1:500 year flood. For Wascana Creek, the Technical Committee requested that the 1974 flood of record be modelled in lieu of the 1:100 year flood. The computer model was also used to determine water surface profiles for proposed floodways.

I

INTRODUCTIO

A. GENERAL

Wascana Creek, a major tributary of the Qu'Appelle River, originates in the Vibank area. From Vibank it flows southeasterly to Tyvan, turns northwest, flowing through Regina and into the Qu'Appelle River approximately 3 kilometres west of Lumsden. Wascana Creek and its tributaries above Regina, drain a gross area of 2165 km^2 as shown on Figure 1 (Banga, 1980).

Wascana Creek flows are due mainly to surface runoff derived from spring snowmelt. Some summer flows do occasionally occur due to rainstorms of high intensity, however, extreme rainfalls - such as the June 25-26, 1975 storm which dumped almost 150 mm of rain in six hours - are required to produce significant runoff. For more complete detail of the hydrology of Wascana Creek, the reader is referred to the Saskatchewan Environment reports: "Flood Peak Potential Wascana Creek at Regina" (Banga, 1980) and "Flood Peak Potential Regina Storm Channels," (Wyngaarden, 1980).

Regina has experienced numerous occasions when flows exceeded the channel capacity. Major damage was sustained in Regina during the floods of 1911, 1925, 1956 and 1971. Minor flooding along the Wascana Creek has occurred in a number of other years as well.

B. THE STUDY

To reduce damages due to flooding, a flood hazard mapping and studies program was initiated under the Canada-Saskatchewan Flood Damage Reduction Program. The Steering Committee requested the Hydrology Branch of Saskatchewan Environment to conduct a hydrologic and hydraulic analysis of Wascana Creek from Richardson through the City of Regina to the city sewage lagoons to identify the flood hazard areas. Included in the analysis were Pilot Butte Creek, Chuka Creek and the North and South Storm Channels located within the city, as shown on Figure 2.

The results of the hydrologic analysis are contained in the two Saskatchewan Environment reports mentioned above.

The purpose of this study was to determine the water surface profiles on Wascana Creek, along the reach from Richardson to the City of Regina sewage lagoons based on the 1:100 year and 1:500 year flood hydrographs and map the floodlines associated with the delineation of a floodway and floodway fringe within the flood hazard area.

Flood elevations were to be determined and mapped for the 1:100 year and 1:500 year peak instantaneous flows on each of the Wascana Creek, Pilot Butte Creek, Chuka Creek and the North and South Regina Storm Channels. Floodway limits corresponding to the 1:500 year event were to be determined and mapped for Wascana Creek and Pilot Butte Creek. At the request of the Technical Committee of the

Canada-Saskatchewan Flood Damage Reduction Program, the 1:100 year event was subsequently substituted with the 1974 flood of record for Wascana Creek.

Floodway limits for Wascana Creek and Pilot Butte Creek were determined using three hydraulic criteria. The floodway is defined as the stream channel plus that part of the floodplain which:

1) is required to convey the entire design flood without raising the natural water surface more than 30 centimetres,

OR

2) lies at a greater depth than one metre below the design flood water surface elevation raised no more than 30 centimetres,

OR

3) lies within the area of flow velocities greater than or equal to one metre per second.

The floodways for each of the three criteria were delineated on the 1:2000 topographic maps for the use of the Technical Committee of the Canada-Saskatchewan Flood Damage Reduction Program. Technical representatives from the City of Regina were consulted on several occasions prior to the delineation of the floodway zones. Figure 3 shows the 1:2000 map coverage for Regina.

II

BASIC INFORMATION

A. RECENT FLOOD HISTORY

The largest recorded floods in Regina occurred in 1925, 1971 and 1974. Of the three floods, the 1971 flood (92 m^3/s) was the most destructive. The 1974 flood (103 m^3/s) had the largest peak flow, but was contained within the dykes constructed after the 1971 flood. Subsequent to the 1974 flood, existing dykes were further raised and modifications were made to the Albert Street weir. Other channel modifications have occurred and hydraulic structures constructed which are dealt with in the report.

B. WATER SURFACE DATA

Since the 1971 and 1974 floods, several above normal flows have been experienced on Wascana Creek through Regina, however, no flood was as well documented as the 1974 event. City and Saskatchewan Environment staff obtained several maximum water surface elevation observations as well as headloss measurements at most of the hydraulic structures between the Highway #1 Bypass bridge and the sewage lagoons. Air photos of Wascana Creek in its peak flood stage were also taken. Because of the exceptionally good documentation, the 1974 flood was used for calibrating the hydraulic model.

Unfortunately, only the gauge readings at the Saskatchewan Environment hydrometric stations at Highway #33 are available for Pilot Butte Creek and Chuka Creek. No headloss measurements are available for calibrating the models of these tributaries.

The only data available for calibration on the North and South Storm Channels were obtained from high water marks measured for the June 23, 1980 runoff which resulted from 21.2 millimetres of rain over Regina.

C. STREAMFLOW DATA

Table 1 shows the flood peak potential from spring snowmelts for Wascana Creek as determined by Banga (Banga 1980). The flood potential for Wascana Creek at the Highway #1 Bypass was found to be slightly higher than for the Richardson location due to the inflow from Pilot Butte Creek. However, the difference was too small to be significant, and a constant flow of 180 m^3/s was used as the design 1:500 year flow for Wascana Creek.

Table 2 shows the 1:100 and 1:500 year flows for the Regina Storm Channels, Pilot Butte Creek and Chuka Creek as determined by Wyngaarden (Wyngaarden 1980). For the storm channels and Chuka Creek, the flows are the result of a summer rainstorm event of the same return period. For Pilot Butte Creek the flows are the result of spring snowmelt.

Streamflow data for the 1974 flood of record was obtained from the hydrometric files of the Hydrology Branch of Saskatchewan Environment. Peak flows of 103 m^3/s were metered at approximately 15:00 hours on April 21, 1974 at the Highway #1 Bypass and below Wascana Lake. The flow was assumed constant from Richardson to the sewage lagoons.

Table 1

FLOOD PEAK POTENTIAL FOR WASCANA CREEK AT REGINA (1)

Return Period (Yrs)	Wascana Creek Near Richardson		Wascana Creek At #1 Hwy. Bypass		Wascana Creek At Albert Street Weir	
	Mean Daily Flow (m^3/s)	Instantaneous Flow (m^3/s)	Mean Daily Flow (m^3/s)	Instantaneous Flow (m^3/s)	Mean Daily Flow (m^3/s)	Instantaneous Flow (m^3/s)
1:2	15	20	15	20	15	20
1:10	50	60	55	65	50	60
1:25	75	85	80	90	75	85
1:50	95	105	100	110	95	105
1:100	115	130	120	135	115	130
1:500	160	180	170	190	160	180

(1) Taken from Banga, 1980.

Table 2

PEAK INSTANTANEOUS FLOWS FOR
REGINA STORM CHANNELS (1)

Stream	Peak Instantaneous Flows (m^3/s)	
	1:100	1:500
Pilot Butte Creek	18	24
Chuka Creek	12	15
North Storm	40	49
South Storm	14	17

(1) Taken from Wyngaarden, 1980.

D. CROSS SECTIONAL DATA

Previous studies by the Prairie Farm Rehabilitation Administration (PFRA) of the Canada Department of Regional Economic Expansion and by the Conservation and Land Improvement Branch (C&LI) - now the Conservation and Development Branch (C&D) - of Saskatchewan Agriculture provided channel cross- sectional information on Wascana Creek downstream of Albert Street and upstream of Fleet Street respectively. The PFRA work was completed in 1972, and the C&LI work in 1977. Where changes had been made, such as in the dyking along Wascana Creek between Albert Street and Elphinstone Street, the channel was cross-sectioned again by Saskatchewan Environment. Further cross-sectional data wereobtained by Saskatchewan Environment on Pilot Butte Creek, Chuka Creek, the North and South Storm Channels and at all hydraulic structures in existence as of the summer of 1978.

Surveyed cross-sections were extended using the 1:2000 scale, 0.5 metre contour interval maps provided under the Canada-Saskatchewan Flood Damage Reduction Program. The cross-section data were prepared as ground co-ordinate tables and plotted on graph paper.

Stations were established along the centre line of the stream channel. The stationing began 15 m upstream of the grid road bridge at the sewage lagoons, and proceeded upstream, increasing in magnitude. Wascana Creek was divided into two reaches:

1) from the sewage lagoons to Albert Street; and
2) from Albert Street to Richardson

Pilot Butte Creek, Chuka Creek and the storm channels were divided into sub-reaches, each beginning at a weir flow control section or where a transition between subcritical and supercritical flow occurred. All crossings were checked for submergence.

Cross-sections were chosen at points along the channel to describe typical channel configuration as well as at such points where there was a change in channel configuration. Distances between cross-sections were kept to a maximum of 500 metres where possible. Cross-sections were also established 15 to 30 metres up and down stream of any hydraulic structure. Cross-section locations are shown on Figure 4.

E. PHOTOGRAPHS

The only photographs used for this study were the airphotos taken on April 22, 1974, one day after the first peak flow of 103 m^3/s

reached Regina. The photos were still considered to be valid for use in calibrating the model since a second peak of 103 m^3/s was observed on April 23, 1974 and flows between the two peaks had not receded to any significant extent. Some ground level photos were available, however, they were not dated and, therefore, could not be used for calibration purposes. Some photos are included at the back of this report to provide an appreciation of the extent of flooding that has occurred in the past and could again occur in the future.

F. COMPUTER PROGRAM

Water surface profiles were determined using the HEC II computer program developed by the U.S. Army Corps of Engineers. The program was run on the facilities of the Saskatchewan Government Computer Centre.

The HEC II program calculates water surface profiles along stream channels and at structures such as weirs and bridges under various flow conditions. The program has the capability for calculating water surface profiles through culverts as well, however, only for submerged conditions. Therefore, the program was stopped at all culvert crossings, and the water surface profile was calculated by hand across the culvert crossing.

The computational procedure of the HEC II program is based on the solution of the one-dimensional energy equation with energy loss due to friction evaluated with Manning's equation. The computational

procedure is generally known as the Standard Step Method. The program is also designed for application in flood plain management to evaluate floodway encroachments and to designate flood hazard zones. The program can also assess the effects of channel improvements and levees on water surface profiles. Input and output may be either in Imperial or Metric units (U.S. Army Corps of Engineers, 1979).

The input data for the HEC II computer program consists of :

(a) cross-sectional data in co-ordinate form
(b) Manning's roughness coefficients for the main channel and overbanks;
(c) headloss coefficients representing the effects of contraction and expansion at hydraulic structures, and the shape of abutments and bridge piers; and
(d) coefficients of discharge for weir flow over bridges and their approaches.

III

PROCEDURES

A. GENERAL

Each cross-section was divided into channel, left overbank and right overbank areas. Since the program calculates the water surface profile going upstream for subcritical flow, for the purposes of this study the left overbank is on the left side facing upstream.

Distances between channel and overbanks of adjacent cross-sections may differ due to the meander of the river within the floodplain. The channel centre line distance was used to identify the cross-sections. Overbank distances, required in the computations, were measured along the contour lines at the water surface elevation determined by the program. Even though the recommended procedure for measuring the overbank distances was to measure the distances between the centroids of overbank flow, the method used was found to be easier and faster, and had no significant effect on the study results.

Manning's roughness coefficients were assigned to the channel and overbank sections. Manning's roughness coefficient depends on such factors as surface roughness of the channel, type and amount of vegetation, channel irregularity and alignment, silting and scouring, obstructions, size and shape of the channel and the flood stage (Chow, 1959). The values used in the model account for the effects of channel configuration (bends, islands, pools), localized

headlosses which have not been defined in the field, and man-made obstructions other than channel structures (roadways, sidewalks, fences, hedges, etc. and variation in vegetation cover in the channel and overbank areas). The left and right overbank areas were given the same roughness coefficient. The roughness coefficients used are contained in Appendix I.

Ice jams were not considered in this study. From the 1974 airphotos no ice was evident in the channel at the time of the peak flow. Similarily, it is assumed that for the lower frequency flood events, the channel would be clear of ice at the time of the peak flow. Furthermore, no analysis of wind effects on the flood profiles was undertaken.

B. WASCANA CREEK - SEWAGE LAGOONS TO ALBERT STREET

The HEC II model was run using the 1974 peak flow of 103 m^3/s and the observed water surface elevation at the upstream side of the grid road at the sewage lagoons. The model was then calibrated by adjusting the Manning's roughness coefficients for the channel and overbanks, and the overbank distances, until a good match was obtained between observed and calculated water surface values.

A HEC II model was run to calculate the profile from the downstream side of the grid road bridge through the bridge. The model was calibrated using the 1974 peak flow of 103 m^3/s, the normal depth of flow as the starting water surface elevation, and an appropriate Manning's roughness coefficient. The normal depth was considered

appropriate as the starting water surface elevation, since the next hydraulic structure is another grid road bridge approximately 7.5 km downstream and, therefore, would have little or no affect on the depth of flow at the sewage lagoons.

The headlosses across bridges were calculated using the special bridge routine except for the 13th Avenue bridge. The 13th Avenue bridge is a perched bridge, that is, in flood stage the flow goes through the left overbank (facing upstream), across 13th Avenue east of the bridge rather than going under the bridge. Therefore, the bridge has no significant hydraulic effect on the rarer floods and was not included into the model, except in the Manning's roughness coefficient.

The bridge parameters were defined as required by the special bridge routine and the appropriate coefficients were adjusted accordingly to duplicate the observed headlosses.

Despite modifications to the dyking between Albert Street and Elphinstone Street and the addition of the McCarthy Boulevard bridges, the 1974 flood was still considered valid for calibration purposes since the 1974 peak flows were contained within the existing dyking and the McCarthy Boulevard bridges have no significant hydraulic effect on the flows, with only a 2 cm headloss calculated for the 1974 flood.

The calibrated model was then used to determine the water surface

profile for the 1:500 year peak flow of 180 m^3/s. The Manning's roughness coefficients determined for the 1974 flood of record were assumed to hold for the 1:500 year flood. Any existing dyking was assumed to be absent in determining the 1:500 year flood elevations. The impact of the dykes was included in the floodway delineation and its effect on the outside boundary of the flood hazard area.

The model was then used to determine the initial location of a 1:500 year floodway. Using method's 4 and 6 of the HEC II Flood Plain Encroachment Option subroutine, encroachments were selected for each cross-section to provide a 30 centimetre rise on the 1:500 year water surface profile. Encroachments were selected in such a manner so as to reduce the conveyance in proportion to the distribution of natural overbank conveyance.

The floodlines for the 1974 flood of record and the 1:500 year flood were then drawn on paper prints of the 1:2000 Flood Hazard Maps supplied. The encroachments producing the 30 cm rise on the 1:500 year flood water surface profile, the one metre depth floodline of the encroached water surface profile, and the 1 metre per second velocity line were also drawn on the paper prints.

Subsequent to the completion of this part of the study, the 13th Avenue bridge was replaced and the road grade raised. The CNR Lewvan Line railway trestle was removed and the A.E. Wilson weir constructed. These changes were incorporated into the model and the floodlines were re-drawn.

C. WASCANA CREEK - ALBERT STREET TO RICHARDSON

The model was run using the 1974 peak flow of 103 m^3/s and the observed water surface elevation from the Saskatchewan Environment hydrometric station, located in the pump house just east of the Legislative Buildings. The model was calibrated by adjusting the Manning's roughness coefficients for the channel and overbanks, and the overbank distances until a good match was obtained between observed and calculated water surface values.

The headlosses across bridges were calculated using the special bridge routine, except for the low level crossings. The low level crossings were all inundated and, therefore, were not accounted for in the model except for in the Manning's roughness coefficient.

The 1974 flood of record was again used for the calibration since no major changes have been made to the hydraulic regime of Wascana Creek above Albert Street except the addition of the west bound bridge of the Highway #1 Bypass. However, the hydraulic effect of the new bridge appears to be negligible because of the backwater effect of the Albert Street Weir.

The calibrated model was used to determine the water surface profile for the 1:500 year peak flow of 180 m^3/s. The starting water surface elevation was determined from the stage-discharge curve for the Albert Street Weir, supplied by PFRA (Forsyth, 1980). The rating curve was valid despite the submergence of the weir crest since, for broad crested weirs and parshall flumes, the crest can be submerged up to 70% of the total head without affecting the discharge (Smith, 1956).

The model was then used to determine the initial location of a 1:500 year floodway. Again, methods 4 and 6 of the Flood Plain Encroachment Option subroutine were used to select the encroachments for each cross-section to provide a 30 centimetre rise on the 1:500 year water surface profile.

The floodlines for the 1974 flood of record and the 1:500 year flood along with the 30 centimetre rise encroachment line, the one metre depth floodline of the encroached water surface profile and the 1 metre per second velocity line were drawn on paper prints of the 1:2000 Flood Hazard Maps supplied.

D. PILOT BUTTE CREEK

The model was run using the calculated water surface elevation for Wascana Creek at the confluence of Pilot Butte Creek (from the Wascana Creek-Albert Street to Richardson calibration run for the 1974 flood of record), and the 1974 peak flow of 7 m^3/s metered at the Saskatchewan Environment hydrometric station "Pilot Butte Creek at Highway #33."

The model was calibrated to the one observed water surface elevation at the hydrometric station. No other observed values or air photos were available to assist in the calibration and, therefore, the Manning's roughness coefficients were assumed constant throughout the entire reach analyzed in this study.

The headlosses across bridges were calculated using the special bridge routine, except for the CNR trestle immediately downstream of the Cindercrete cement plant on Fleet Street for which the normal bridge routine was used (U.S. Army Corps of Engineers, 1979). Headlosses across culvert crossings were calculated by hand (Corrugated Steel Pipe Institute).

The calibrated model was used to determine the water surface profiles for the 1:100 year peak flow of 18 m^3/s and the 1:500 year peak flow of 24 m^3/s. The starting water surface elevations were obtained from the Wascana Creek-Albert Street to Richardson run for the 1:100 and 1:500 year events at the confluence of Pilot Butte Creek.

Similar to Wascana Creek the initial location of a 1:500 year floodway was determined using methods 4 and 6 of the Flood Plain Encroachment Option subroutine. Encroachments were selected to provide a 30 centimetre rise in the 1:500 year water surface profile.

The floodlines for the 1:100 and 1:500 year floods along with the 30 centimetre rise encroachment line, the 1 metre depth floodline of the encroached water surface profile and the 1 metre per second velocity line were drawn on paper prints of the 1:2000 Flood Hazard Maps supplied.

During 1980, the City of Regina dredged Pilot Butte Creek and straightened the channel from the confluence to the CNR trestle at the Cindercrete plant and from the drive-in theatre to the old dugouts immediately downstream of Dewdney Avenue. The major changes to Pilot Butte Creek due to the dredging is the deepening and straightening of the channel, the removal of the abandoned railway crossing upstream of Highway #33, the construction of the Truesdale Drive crossing and the removal of the Fleet Street crossing. The culverts at the Assiniboine Avenue crossing were also lowered to accommodate the deepening of the channel. The dredged channel centre-line location is shown on the 1:2000 Flood Hazard Maps.

The Steering Committee, subsequently, asked the Hydrology Branch of Saskatchewan Environment to conduct a hydraulic analysis on the dredged Pilot Butte Creek for the 1:500 year flood.

Since no flow data is available for the dredged creek, the same Manning's roughness coefficients were used. The starting water surface elevations for the 1:100 and 1:500 year floods do not change. The new 1:500 year floodlines were then plotted on the 1:2000 Flood Hazard Maps.

E. SOUTH STORM CHANNEL

The 1:100 and 1:500 year flood events for the South Storm Channel are the result of summer rainstorm events of the same return period (Wyngaarden, 1980). The June 23, 1980 storm which produced a

calculated peak flow of 3.82 m^3/s on the South Storm Channel at Pasqua Street was used to calibrate the model. The flow was assumed constant for the entire channel.

Since the Wascana Creek normal summer water surface elevations have no effect on the flow levels in the South Storm Channel, the normal depth of flow was used as the starting water surface elevation assuming an appropriate Manning's roughness coefficient.

The model was calibrated to the observed water surface elevations taken at Pasqua Street by adjusting the Manning's roughness coefficients and the starting water surface elevation accordingly until a good match between calculated and observed water surface elevations was obtained.

The headlosses across bridges were calculated using the special bridge routine. Headlosses across culvert crossings were calculated by hand (Corrugated Steel Pipe Institute).

The calibrated model was then used to determine the water surface profiles for the 1:100 year peak flow of 14 m^3/s and the 1:500 year peak flow of 17 m^3/s. Normal depths of flow were calculated for each of the flows at the confluence with Wascana Creek as the starting water surface elevations. The floodlines were drawn on paper prints of the 1:2000 Flood Hazard Maps. No floodway was required for the South Storm Channel.

Subsequent to the completion of this part of the study, the CNR

Lewvan Line railway trestle was removed from across the South Storm Channel. This change was incorporated into the model and the floodlines re-drawn.

F. NORTH STORM CHANNEL

For the North Storm Channel, 1:100 and 1:500 flood events are also the result of summer rainstorm events of the same return period (Wyngaarden, 1980). The June 23, 1980 storm which produced a calculated peak flow of 9.8 m^3/s on the North Storm Channel at Courtney Street was used to calibrate the model. As with the South Storm channel, the normal depth of flow was used as the starting water surface elevation, assuming an appropriate Manning's roughness coefficient.

The model was calibrated to the observed water surface elevations taken at Courtney Street by adjusting the Manning's roughness coefficients and the starting water surface elevation accordingly until a good match between calculated and observed water surface elevations was obtained.

Headlosses across culvert crossings were calculated by hand (Corrugated Steel Pipe Institute).

The calibrated model was used to determine the water surface profiles for the 1:100 year peak flow of 40 m^3/s and the 1:500 year peak flow of 49 m^3/s. Normal depths of flow were calculated at the confluence with Wascana Creek for each of the flows as the starting water surface elevations.

Water surface profiles for the Northwest Branch and North Branch of the North Channel were also determined for the 1:100 and 1:500 year events. Starting water surface elevations were obtained from the North Storm Channel at the confluence for each branch. Peak flows were determined by the hydrology study (Wyngaarden, 1980).

The 1:100 and 1:500 year floodlines were drawn on paper prints of the 1:2000 Flood Hazards Maps. No floodway was required for the North Storm Channel.

Subsequent to the completion of this part of the study, the Courtney Street crossing of the North Storm Channel was removed. This change was incorporated into the model and the floodlines re-drawn.

G. CHUKA CREEK

Unlike Pilot Butte Creek, the 1:100 and 1:500 year flood events for Chuka Creek are the result of summer rainstorm events of the same return period (Wyngaarden, 1980). However, no summer flow data is available for Chuka Creek and, therefore, the model was calibrated using the 1979 spring flood for which a peak flow of 4.5 m^3/s was metered at the Saskatchewan Environment hydrometric station "Chuka Creek at Highway #33". The normal depth of flow was used as the starting water surface elevation, assuming an appropriate Manning's roughness coefficient.

The model was calibrated to the observed water surface elevation taken at the Highway #33 hydrometric station by adjusting the

Manning's roughness value and the starting water surface elevation accordingly until a good match between calculated and observed water surface elevations was obtained.

Headlosses across bridges were calculated using the special bridge routine.

The calibrated model was used to determine the water surface profiles for the 1:100 year peak flow of 12 m^3/s and the 1:500 year peak flow of 15 m^3/s. Starting water surface elevations were calculated at the confluence with Wascana Creek for each of the flows. The floodlines were then drawn on paper prints of the 1:2000 Flood Hazard Maps. No floodway was required for Chuka Creek.

H. FLOODWAY DELINEATION

Given the 1:2000 Flood Hazard Maps with the floodway criteria lines and flood hazard lines, the Technical Committee, in consultation with the Steering Committee and the City of Regina, optimized the floodway location. Optimization was based on land use and hydraulic considerations. Several iterations of floodway relocation and computer modelling were required before final floodway and flood hazard areas were obtained. Method 1 of the Flood Plain Encroachment Option subroutine which utilizes pre-determined floodway encroachment stations was used for the floodway iterations.

IV

RESULTS

A. WASCANA CREEK - SEWAGE LAGOONS TO ALBERT STREET

The starting water surface elevation calculated for the model through the grid road bridge at the sewage lagoons was 564.60 metres geodetic for the 1974 peak flow of 103 m^3/s. Running the model through the bridge, it calculated a water surface elevation of 564.76 metres at the upstream side of the bridge compared to the observed elevation of 564.79. Despite the good agreement between observed and calculated water surface elevations, the observed value was used for the model from the sewage lagoons to Albert Street since it was an observed value and, therefore, considered to be more accurate.

Table 3 shows the results of the calibration of the HEC II model for Wascana Creek from the sewage lagoons to Albert Street. For the model calibration, the computed water surface elevation (CWSEL) was used rather than the total energy elevations (EG), since the observed values were taken from the bridges at the centre of the channel. The difference between the observed and calibrated water surface elevations did not exceed 0.14 metres and the mean difference was approximately 0.05 metres.

Manning's roughness coefficients for the channel varied from 0.025 to 0.045 and from 0.050 to 0.075 for the left and right overbank areas. These values are comparable to those outlined by Chow (Chow, 1959). The Computed Manning's roughness coefficients for the entire reach are listed in Appendix 1.

Table 3

WASCANA CREEK CALIBRATION RESULTS - SEWAGE LAGOONS TO ALBERT STREET

Elevations to Geodetic Datum in Metres*

Station	Station Description	Water Surface Elevation	
		Observed (metres geodetic)	Calibrated (metres geodetic)
0	15 m u/s of grid road N of Sewage lagoons	564.79	564.79
3100	U/S face grid road N of cement plant	565.82	565.77
7325	D/S face CNR trestle at Toothill Street	567.12	567.06
7328	U/S face CNR trestle at Toothill Street	567.14	567.09
13426	D/S face Dewdney Avenue	568.39	568.51
13456	U/S face Dewdney Avenue	568.42	568.50
15604	D/S face CPR bridge	568.93	568.92
15612	U/S face CPR bridge	568.96	568.92
17414	D/S face CNR trestle (Lewvan Line)	569.48	569.43
17422	U/S face CNR trestle (Lewvan Line)	569.52	569.46
17574	Between Pasqua St. and Edward St. Weir	569.57	569.57
17619	D/S face Pasqua Street	569.64	569.63
17637	U/S face Pasqua Street	569.72	569.63
17667	30 m U/S of Pasqua Street	569.69	569.69
18357	30 m D/S of Elphinstone Street	569.78	569.84
18387	D/S face Elphinstone Street	569.74	569.84
18405	U/S face Elphinstone Street	569.85	569.85
18493	U/S of Elphinstone Street	569.86	570.00
19100	U/S face Cameron Street footbridge	569.99	570.05

* Although the computed values in this table are shown to two decimal places to better illustrate the difference in elevation between cross-sections and between flood events, water surface elevations cannot be realistically predicted to this degree of accuracy.

The starting water surface elevation for the 1:500 year flow of 180 m^3/s was 565.25 metres, downstream of the grid road bridge at the sewage lagoons. A total energy elevation of 565.64 metres was calculated as the starting elevation for Wascana Creek at the sewage lagoons. The starting elevation of 565.77 m for the floodway was calculated using the slope-area method of the HEC II computer model, by entering an estimated energy slope and an approximate water

surface elevation. This was done to account for the encroachment at the start of the reach, and allows for encroachment downstream of the reach analyzed.

Two runs were made for the 1:500 year design flood. The first represents the conditions as they were in the spring of 1978 at the time the photography for the 1:2000 maps was done. The second represents present existing conditions which include the modifications made by the City of Regina subsequent to the 1978 photography. These modifications include the construction of the A.E. Wilson weir, the new 13th Avenue bridge and the removal of the Lewvan Line bridge.

Table 4 summarizes the water surface profiles for the 1974 flood of record and the computed design 1:500 year flood with and without the floodway, under the 1978 and present existing conditions.

One can see in comparing the 1:500 year design flood profiles that the rise in water surface elevations due to the floodway encroachment remains within the 30 centimetre rise criteria. In locating a floodway, the FDR Technical and Steering Committees along with technical representatives from the City of Regina assumed the existing dyking at Mount Royal and Riverside to be a means of flood protection for the purpose of delineating a floodway zone. However, these dykes are overtopped by the design flood from Dewdney Avenue to 8th Avenue and at Elphinstone Street respectively. If these dykes are to be considered a means of flood protection, they must be examined further on several aspects.

Table 4
WASCANA CREEK - SEWAGE LAGOONS TO ALBERT STREET
TOTAL ENERGY ELEVATIONS FOR FLOOD FLOWS

Elevations to Geodetic Datum in metrest

Station	Cross-section Location	1974	Flood Events			
			1:500 year flood		1:500 year flood with floodway	
			1978	Present *	1978	Present *
0	15 m U/S of grid road @ sewage lagoons	564.82	565.64	565.64	565.77	565.77
660		565.02	565.83	565.83	565.96	565.96
1180		565.17	565.98	565.98	566.09	566.09
1755		565.36	566.13	566.13	566.22	566.22
2265		565.55	566.29	566.29	566.36	566.36
2755		565.70	566.44	566.44	566.50	566.50
3075		565.82	566.55	566.55	566.60	566.60
3088		565.82	566.57	566.57	566.62	566.62
3090	D/S face grid road	565.83	566.58	566.58	566.64	566.64
3100	U/S face grid road	565.83	566.72	566.72	566.79	566.79
3102		565.83	566.73	566.73	566.79	566.79
3115		565.84	566.74	566.74	566.81	566.81
3395		565.90	566.79	566.79	566.85	566.85
3855		566.03	566.86	566.86	566.92	566.92
4375		566.22	566.97	566.97	567.04	567.04
5060		566.47	567.13	567.13	567.19	567.19
5415		566.56	567.18	567.18	567.23	567.23
5715		566.63	567.23	567.23	567.27	567.27
6135		566.80	567.36	567.36	567.39	567.39
6615		566.96	567.49	567.49	567.52	567.52
7010		567.04	567.56	567.56	567.59	567.59
7310		567.09	567.60	567.60	567.63	567.63
7325	D/S face CNR trestle @ Toothill Street	567.13	567.71	567.71	567.74	567.74
7328	U/S face CNR trestle @ Toothill Street	567.16	567.78	567.78	567.80	567.80
7358		567.17	567.79	567.79	567.82	567.82
7818		567.23	567.84	567.84	567.87	567.87

Table 4 (continued)

Station Present	Cross-section Location	Flood Events				
		1974	1:500 year flood		1:500 year flood with floodway	
			1978	Present *	1978	Present *
8083		567.27	567.87	567.87	567.90	567.90
8113	D/S face Boy's School bridge	567.33	568.00	568.00	568.03	568.03
8121	U/S face Boy's School bridge	567.46	568.10	568.10	568.11	568.11
8151		567.47	568.12	568.12	568.13	568.13
8891		567.50	568.15	568.15	568.17	568.17
9351		567.51	568.15	568.15	568.17	568.17
10031		567.54	568.17	568.17	568.19	568.19
10047		567.58	568.20	568.20	568.22	568.22
10647		567.69	568.29	568.29	568.32	568.32
10998	D/S side A.E. Wilson Weir	567.74	568.33	568.34	568.36	568.38
11002		567.74	568.33	568.34	568.36	568.38
11003.5		567.74	568.33	568.34	568.36	568.38
11007	U/S side A.E. Wilson Weir	567.74	568.34	568.35	568.37	568.38
11220		567.77	568.36	568.37	568.39	568.40
11540		567.85	568.43	568.44	568.47	568.47
11940		567.99	568.55	568.56	568.59	568.59
12230		568.03	568.59	568.60	568.63	568.63
12580		568.08	568.65	568.66	568.69	568.69
12608		568.12	568.74	568.75	568.77	568.78
12610	D/S face McCarthy Blvd.	568.12	568.74	568.75	568.78	568.78
12620		568.12	568.75	568.75	568.78	568.79
12621		568.13	568.76	568.77	568.79	568.80
12623		568.13	568.76	568.77	568.79	568.80
12633	U/S face McCarthy Blvd.	568.13	568.76	568.77	568.80	568.80
12636		568.14	568.78	568.79	568.81	568.82
12666		568.15	568.80	568.80	568.83	568.83
13006		568.19	568.83	568.83	568.87	568.88
13236		568.22	568.87	568.87	568.93	568.94
13244	D/S face 8th Ave. Weir and footbridge	568.46	569.22	569.22	569.24	569.24
13246	U/S face 8th Ave. Weir and footbridge	568.46	569.22	569.22	569.24	569.24

Table 4 (continued)

Station	Cross-section Location	Flood Events				
		1974	1:500 year flood		1:500 year flood with floodway	
			1978	Present *	1978	Present *
13336		568.54	569.24	569.25	569.29	569.29
13424		568.56	569.28	569.29	569.33	569.33
13426	D/S face of Dewdney Avenue	568.56	569.29	569.29	569.33	569.34
13439		568.56	569.29	569.29	569.41	569.41
13441		568.58	569.30	569.30	569.43	569.43
13443		568.58	569.30	569.31	569.43	569.43
13456	U/S face of Dewdney Avenue	568.58	569.30	569.31	569.48	569.48
13458		568.58	569.31	569.31	569.49	569.49
13465		568.59	569.32	569.32	569.50	569.50
13545		568.61	569.34	569.34	569.51	569.51
13615		568.62	569.35	569.35	569.52	569.52
13745		568.63	569.35	569.35	569.52	569.52
14035	At Horace Street	568.66	569.38	569.38	569.54	569.54
14375		568.72	569.41	569.41	569.57	569.57
14635		568.77	569.44	569.44	569.58	569.59
14659		568.82	569.46	569.46	569.60	569.60
14661	D/S face 11th Avenue	568.84	569.48	569.48	569.61	569.61
14672	U/S face 11th Avenue	568.87	569.48	569.48	569.61	569.61
14674		568.91	569.49	569.49	569.62	569.63
14702		568.92	569.50	569.50	569.63	569.63
14982		568.94	569.52	569.52	569.65	569.65
15282		568.95	569.53	569.53	569.65	569.66
15562		568.95	569.54	569.54	569.66	569.66
15602	D/S wingwall CPR bridge	569.09	569.81	569.81	569.91	569.91
15604	D/S face CPR bridge	569.13	569.90	569.90	570.00	570.00
15612	U/S face CPR bridge	569.13	569.91	569.91	570.09	570.09
15614	U/S wingwall CPR bridge	569.14	569.97	569.97	570.15	570.15
15654		569.17	570.02	570.02	570.18	570.18
15744		569.18	570.02	570.02	570.19	570.19
15884		569.19	570.03	570.03	570.19	570.19

Table 4 (continued)

Station	Cross-section Location	Flood Events				
			1:500 year flood		1:500 year flood with floodway	
		1974	1978	Present *	1978	Present *
15886	D/S face 13th Avenue	569.19	570.03	570.04	570.19	570.21
15896	U/S face 13th Avenue	569.20	570.03	570.05	570.20	570.22
15898		569.20	570.03	570.06	570.20	570.23
15924		569.20	570.03	570.06	570.20	570.23
16434		569.24	570.05	570.08	570.22	570.25
16934		569.32	570.11	570.13	570.26	570.29
17384		569.42	570.20	570.22	570.33	570.36
17412		569.48	570.28	570.30	570.40	570.42
17414	D/S face CNR trestle (Lewvan Line)	569.49	570.29	570.31	570.41	570.43
17422	U/S face CNR trestle (Lewvan Line)	569.52	570.47	570.32	570.55	570.44
17424		569.54	570.48	570.34	570.56	570.45
17474		569.57	570.51	570.38	570.58	570.48
17524	Edward Street Weir	569.61	570.52	570.40	570.59	570.50
17574		569.65	570.53	570.40	570.60	570.50
17617		569.68	570.57	570.45	570.64	570.55
17619	D/S face Pasqua Street	569.69	570.59	570.47	570.67	570.58
17637	U/S face Pasqua Street	569.71	570.59	570.49	570.75	570.68
17639		569.72	570.63	570.52	570.79	570.72
17667		569.73	570.64	570.54	570.80	570.73
18087	At Coronation Street	569.82	570.71	570.62	570.86	570.79
18357		569.89	570.78	570.69	570.91	570.85
18385		569.90	570.79	570.71	570.92	570.86
18387	D/S face Elphinstone Street	569.92	570.80	570.72	570.92	570.87
18405	U/S face Elphinstone Street	569.95	570.80	570.72	570.92	570.87
18407		570.00	570.83	570.82	570.95	570.90
18413	Elphinstone Weir	570.00	570.83	570.82	570.95	570.90
18493		570.01	570.83	570.82	570.96	570.91
18613		570.02	570.84	570.83	570.96	570.91
18733		570.03	570.84	570.83	570.96	570.91
18863		570.06	570.87	570.86	570.99	570.94

Table 4 (continued)

Station	Cross-section Location	Flood Events				
		1974	1:500 year flood		1:500 year flood with floodway	
			1978	Present *	1978	Present *
18958		570.07	570.88	570.87	571.00	570.96
19098	D/S face Cameron Street footbridge	570.09	570.92	570.91	571.03	570.99
19100	U/S face Cameron Street footbridge	570.09	570.92	570.91	571.10	571.06
19225		570.15	570.95	570.94	571.19	571.15
19295		570.18	570.97	570.96	571.23	571.19
19415		570.20	571.00	570.99	571.26	571.23
19545		570.21	571.01	571.01	571.27	571.24
19625	D/S face Albert Street	570.23	571.04	571.03	571.30	571.26

† although the computed values in this table are shown to two decimals to better illustrate the difference in total energy between cross-sections and between flood events, total energy elevations cannot be realistically predicted to this degree of accuracy.

* elevations reflect present existing conditions with the new bridge at 13th Avenue in place and the CNR trestle at the Lewvan line removed, and the A.E. Wilson weir constructed.

The existing dykes at the CPR Annex are not considered as permanent flood protection since the City of Regina has re-zoned this area prohibiting any re-development or new development.

Comparing the results in Table 4, one can see that the new A.E. Wilson weir has virtually no effect on the water surface profiles for the design flood. The new 13th Avenue bridge has virtually no effect on the 1:500 year flood profiles as well. The removal of the CNR Lewvan Line has resulted in a reduced headloss of 0.11 m. This effect is still felt at Albert Street, where the flood profile is still 0.04 m below the 1978 flood profile.

Figure 5 shows the water surface profiles graphically for the 1974 flood of record and the 1:500 year design flood with the floodway, for the present existing conditions.

The greatest headloss for the 1:500 year design flood occurs at the 8th Avenue weir and footbridge where a total headloss of 0.37 m has been computed. The CPR bridge has a net computed headloss of 0.20 m and the CNR trestle at Toothill Street a computed headloss of 0.19 m. The headloss computed across McCarthy Blvd. is 0.04 m.

B. WASCANA CREEK - ALBERT STREET TO RICHARDSON

The starting water surface elevation for the 1974 flood in the Albert Street to Richardson reach was 572.23 m as observed at the Saskatchewan Environment hydrometric station "Wascana Lake below Broad Street Weir," now operated by Water Survey of Canada (WSC) as "Wascana Lake at the Marina."

Table 5 shows the results of the model calibration. The observed water surface elevations upstream of the Highway #1 Bypass were estimated from airphotos. The difference between the observed and calibrated water surface elevations did not exceed 0.12 metres and the mean difference was approximately 0.06 metres.

Table 5

WASCANA CREEK CALIBRATION RESULTS - ALBERT STREET TO RICHARDSON

Elevations to Geodetic Datum in metres*

Station	Station Description	Water Surface Elevation	
		Observed (m)	Calibrated (m)
0	U/S face Albert Street bridge	572.23	572.23
5182	D/S face Highway #1 Bypass (old bridge)	572.67	572.63
5214	U/S face Highway #1 Bypass (old bridge)	572.75	572.65
8798	U/S face Fleet Street	572.75P	572.80
17400		572.90P	573.02
19098	U/S face E-W Grid Road	573.20P	573.17
20220		573.40P	573.42

* although the computed values in this table are shown to two decimal places to better illustrate the difference in elevation between cross-sections and between flood events, water surface elevations cannot be realistically predicted to this degree of accuracy.

P Water Surface elevation estimated from Air photos.

Manning's roughness coefficient remained constant at 0.030 for the channel and 0.050 for the left and right overbank.

The starting water surface elevation for the 1:500 year flood event was 572.82 metres, as derived from the PFRA rating curve for the Albert Street Weir for a flow of 180 m^3/s. The starting elevation for the floodway encroachment was also 572.82 metres as determined from the PFRA rating curve for the Albert Street Weir.

Table 6 summarizes the water surface profiles for the 1974 flood of record and the computed design 1:500 year flood with and without the floodway. Figure 6 shows the water surface profiles for the 1974 and 1:500 year floods.

Comparing the 1:500 year design profiles, one can note that the floodway encroachment results in minimal rise in the water surface profile. This is due, in large part, to the backwater effect of the Albert Street Weir, a very flat river channel gradient, and the floodway encroachment tends to be in areas of little or no hydraulic conveyance owing to depth criteria considerations.

The greatest headlosses for the 1:500 year flood occur at the Broad Street bridge and weir with a total headloss of 0.71 m followed by the Highway #1 Bypass bridges with a total headloss of 0.22 m.

C. PILOT BUTTE CREEK

1. Pre-dredged Conditions

Using a starting water surface elevation of 572.78 m - obtained from the Wascana Creek-Albert Street to Richardson calibration run - a Manning's roughness coefficient of 0.050 was determined for the channel and overbanks. With the Manning's roughness coefficients equal to 0.050, the water surface elevation calculated at Highway #33 was 574.23 m compared to the observed elevation of 574.17 m. For the calibration run, the culvert crossing at Assiniboine Avenue was omitted since it was breached for the 1974 flood.

Table 6

WASCANA CREEK - ALBERT STREET TO RICHARDSON
TOTAL ENERGY ELEVATIONS FOR FLOOD FLOWS

Elevations to Geodetic Datum in metres†

Station	Cross-section Location	Flood Events		
		1974	1:500	1:500 with floodway
0	U/S face Albert Street bridge	572.24	572.82	572.82
200		572.25	572.83	572.83
600		572.25	572.83	572.84
940		572.25	572.84	572.84
1320		572.26	572.84	572.84
1470		572.26	572.84	572.84
1490		572.26	572.84	572.84
1515		572.26	572.84	572.84
1605		572.26	572.84	572.84
1700		572.27	572.86	572.86
1707	D/S face Broad Street	572.46	573.18	573.18
1727	U/S face Broad Street	572.49	573.39	573.39
1735		572.62	573.57	573.57
1830		572.62	573.57	573.58
2370		572.62	573.58	573.58
2740		572.63	573.58	573.58
3030		572.63	573.58	573.58
3430		572.63	573.58	573.58
3760		572.63	573.58	573.58
3980		572.63	573.58	573.58
4360		572.63	573.58	573.58
4710		572.63	573.58	573.59
5010		572.64	573.59	573.59
5160		572.65	573.59	573.60
5168	D/S face Highway #1 Bypass	572.70	573.62	573.63
5182		572.70	573.64	573.64
5194		572.71	573.64	573.64
5199		572.72	573.70	573.69
5214	U/S face Highway #1 Bypass	572.72	573.75	573.75
5228		572.74	573.81	573.81
5470		572.75	573.82	573.82
5750		572.75	573.82	573.82
6150		572.76	573.82	573.82
6530		572.76	573.82	573.82
6830		572.76	573.82	573.82
7110		572.76	573.82	573.82
7510		572.77	573.82	573.83

Table 6 (continued)

Station	Cross-section Location	Flood Events 1974	1:500	1:500 with floodway
7930		572.77	573.83	573.83
8370		572.78	573.83	573.83
8760		572.79	573.84	573.84
8790	D/S face Fleet Street (Rainbow bridge)	572.79	573.84	573.84
8798	U/S face Fleet Street	572.80	573.85	573.85
8830		572.80	573.85	573.86
9030		572.81	573.85	573.86
9490		572.81	573.85	573.86
9810		572.81	573.86	573.86
10120		572.82	573.86	573.86
10430		572.82	573.86	573.86
10750		572.83	573.86	573.87
11240		572.83	573.86	573.87
11275	McKell's Crossing	572.83	573.86	573.87
11310		572.83	573.87	573.87
11690		572.84	573.87	573.87
11840		572.84	573.87	573.87
12310		572.85	573.87	573.88
12620		572.86	573.88	573.88
12940		572.87	573.88	573.89
13420		572.88	573.89	573.89
13720		572.89	573.89	573.90
14180		572.90	573.90	573.90
14500		572.91	573.90	573.91
14950		572.91	573.91	573.91
15410		572.93	573.92	573.92
15870		572.97	573.93	573.93
16330		572.99	573.93	573.94
16630		573.00	573.93	573.94
17100		573.01	573.94	573.94
17400		573.02	573.94	573.95
17850		573.07	573.95	573.97
18310		573.10	573.97	573.99
18620		573.12	573.98	574.01
18930		573.16	573.99	574.03
19060		573.19	574.00	574.03
19090	D/S face E-W Grid Road	573.21	574.01	574.05
19098	U/S face E-W Grid Road	573.23	574.04	574.07
19130		573.26	574.05	574.08
19560		573.32	574.08	574.12
19860		573.38	574.11	574.14
20220		573.42	574.13	574.17

† although the computed values in this table are shown to two decimals to better illustrate the difference in total energy between cross-sections and between flood events, total energy elevations cannot be realistically predicted to this degree of accuracy.

The starting water surface elevations for the 1:100 year flood event and the 1:500 year flood event were 573.15 m and 573.83 m respectively, and were obtained from the corresponding runs for Wascana Creek-Albert Street to Richardson.

Table 7 summarizes the water surface profiles for the computed design 1:100 and 1:500 year floods. Figure 7 shows the 1:100 and 1:500 year flood water surface profiles for the pre-dredged conditions.

The greatest headlosses occur at the culvert crossings of Pilot Butte Creek. The north-south grid road creates the largest single headloss of 1.55 m for the 1:500 year flood followed by Assiniboine Avenue, the abandoned railroad crossing and the east-west grid road with losses of 1.09 m, 1.06 m and 0.79 m respectively.

For all the culvert crossings, the culvert capacities were too small for the 1:100 year and 1:500 year flood flows causing the water to back up until weir flow occurred.

For the bridges, the greatest headloss occurs at Highway #33 with a total loss of 0.38 m for the 1:500 year flood, followed by Dewdney Avenue with a loss of 0.27 m. Relatively small losses occur at the Trans-Canada Highway and the accompanying access roads.

Table 7

PILOT BUTTE CREEK - PRE-DREDGED
TOTAL ENERGY ELEVATIONS FOR FLOOD FLOWS

Elevations to Geodetic Datum in metrest

Station	Cross-section Location	Flood Events 1:100	1:500
0	At confluence	573.15	573.83
340		573.16	573.83
820		573.22	573.85
920		573.26	573.86
950	D/S face Assiniboine Avenue	573.27	573.86
968	U/S face Assiniboine Avenue	574.60	574.95
988		574.60	574.95
1130		574.60	574.95
1590		574.61	574.96
1930		574.63	574.97
2080		574.65	574.99
2200		574.73	575.03
2210	D/S face Highway #33	574.88	575.21
2221	U/S face Highway #33	574.95	575.30
2231		575.04	575.41
2266		575.04	575.41
2273	D/S face abandoned RR crossings	575.04	575.41
2281	U/S face abandoned RR crossings	576.14	576.47
2295		576.14	576.47
2385		576.14	576.47
2475		576.14	576.47
2635		576.14	576.47
2715		576.14	576.47
2805	D/S face Fleet Street	576.15	576.48
2820	U/S face Fleet Street	576.16	576.48
2890		576.16	576.48
2990		576.16	576.48
3090		576.16	576.48
3210		576.16	576.48
3420		576.17	576.49
3700		576.21	576.52
3870		576.22	576.53
3960		576.22	576.53
3966	D/S face CNR trestle	576.26	576.57
3970	U/S face CNR trestle	576.30	576.61
3980		576.30	576.61
4020		576.30	576.61

Table 7 (continued)

Station	Cross-section Location	Flood Events 1:100	1:500
4140		576.31	576.62
4170		576.33	576.62
4180	D/S face cement plant bridge	576.42	576.65
4185	U/S face cement plant bridge	576.45	576.65
4295		576.51	576.72
4395		576.58	576.77
4475		576.77	576.91
4675		577.06	577.16
4775		577.14	577.24
4803		577.25	577.40
4805	D/S face south access road	577.26	577.41
4813	U/S face south access road	577.27	577.43
4815		577.28	577.44
4828		577.35	577.54
4830	D/S face south lanes Highway #1	577.36	577.55
4840	U/S face south lanes Highway #1	577.36	577.56
4842		577.39	577.58
4851		577.43	577.64
4853	D/S face north lanes Highway #1	577.44	577.64
4863	U/S face north lanes Highway #1	577.44	577.65
4865		577.45	577.66
4885		577.51	577.73
4887	D/S face north access road	577.51	577.74
4896	U/S face north access road	577.52	577.74
4898		577.52	577.75
5010		577.57	577.80
5310		577.65	577.86
5500		577.74	577.92
5660		577.81	577.98
5890		578.15	578.19
5950		578.24	578.23
5985		578.27	578.29
6030		578.29	578.33
6150		578.30	578.35
6160	D/S face Dewdney Avenue	578.38	578.48
6170	U/S face Dewdney Avenue	578.39	578.51
6185		578.46	578.62
6535		578.76	578.92
6790		579.01	579.15
7080		579.38	579.49
7110	D/S face N-S grid road	579.40	579.51

Table 7 (continued)

Station	Cross-section Location	Flood Events 1:100	1:500
7125	U/S face N-S grid road	580.90	581.06
7605		580.91	581.07
8005		580.92	581.09
8405		580.97	581.14
8645		581.06	581.21
8860		581.32	581.43
9060	D/S face E-W grid road	581.50	581.61
9071	U/S face E-W grid road	582.30	582.40
9140		582.30	582.41
9460		582.40	582.52
9495	D/S face N-S grid road	582.45	582.56

† although the computed values in this table are shown to two decimals to better illustrate the difference in total energy between cross-sections and between flood events, total energy elevations cannot be realistically predicted to this degree of accuracy.

2. Dredged Conditions

Since no major runoff events have occurred since the dredging of Pilot Butte Creek, the new model could not be calibrated. Therefore, the same Manning's roughness coefficients as for the pre-dredged conditions were used. Starting water surface elevations for the 1:100 year and 1:500 year design floods were also the same since they are determined by the Wascana Creek flood elevations and, therefore, are not affected by the dredging.

Table 8 summarizes the water surface profiles for the computed design 1:100 year flood and 1:500 year flood with and without the floodway. Figure 8 shows the 1:100 and 1:500 year flood water surface profiles for the dredged conditions.

Table 8
PILOT BUTTE CREEK - DREDGED
TOTAL ENERGY ELEVATIONS FOR FLOOD FLOWS

Elevations to Geodetic Datum in metrest

Station	Cross-section Location	Flood Events 1:100	1:500	1:500 with floodway
0	At confluence	573.15	573.83	573.83
300		573.16	573.83	573.83
730		573.18	573.84	573.84
830		573.20	573.85	573.85
851	D/S face Assiniboine Avenue	573.21	573.85	573.85
869	U/S face Assiniboine Avenue	574.83	574.98	574.98
890		574.83	574.98	574.98
1020		574.83	574.98	574.98
1420		574.83	574.99	574.99
1800		574.84	575.00	575.00
1950		574.85	575.01	575.01
2050		574.86	575.02	575.02
2060	D/S face Highway #33	574.92	575.11	575.11
2071	U/S face Highway #33	574.92	575.11	575.11
2080		574.97	575.18	575.18
2120		574.97	575.19	575.19
2230		574.98	575.20	575.20
2310		574.99	575.20	575.20
2470	D/S face Truesdale Drive	575.01	575.23	575.23
2507	U/S face Truesdale Drive	575.31	575.73	575.73
2535		575.31	575.73	575.73
2610	Centre Line Fleet Street (breached)	575.32	575.74	575.74
2685		575.32	575.74	575.74
2765		575.33	575.75	575.75
2865		575.34	575.75	575.75
2975		575.35	575.76	575.77
3175		575.37	575.78	575.79
3415		575.45	575.83	575.85
3545		575.64	575.91	575.92
3575		575.71	575.92	575.93
3581	D/S face CNR trestle	575.81	576.03	576.04
3585	U/S face CNR trestle	575.96	576.18	576.19
3595		575.96	576.19	576.20
3635		575.97	576.19	576.20
3755		576.03	576.23	576.23

Table 8 (continued)

Station	Cross-section Location	Flood Events 1:100	1:500	1:500 with floodway
3785		576.08	576.26	576.26
3795	D/S face Cement plant bridge	576.21	576.46	576.46
3800	U/S face cement plant bridge	576.28	576.47	576.63
3900		576.37	576.58	576.70
4000		576.46	576.66	576.76
4070		576.56	576.74	576.81
4260		576.70	576.86	576.91
4360		576.80	576.95	576.98
4385		576.84	576.99	577.02
4387	D/S face south access road	576.86	577.03	577.05
4395	U/S face south access road	576.86	577.03	577.06
4397		576.88	577.06	577.09
4405		576.89	577.08	577.10
4413		576.94	577.14	577.16
4415	D/S face south lanes Highway #1	576.94	577.15	577.17
4425	U/S face south lanes Highway #1	576.95	577.16	577.18
4427		576.96	577.17	577.19
4431		576.98	577.18	577.20
4436		577.01	577.22	577.24
4438	D/S face north lanes Highway #1	577.02	577.24	577.26
4448	U/S face north lanes Highway #1	577.02	577.24	577.26
4450		577.03	577.26	577.28
4461		577.09	577.32	577.34
4472		577.13	577.37	577.39
4474	D/S face north access road	577.14	577.38	577.40
4483	U/S face north access road	577.14	577.39	577.41
4485		577.15	577.40	577.42
4590		577.21	577.46	577.48
4755		577.27	577.50	577.52
4905		577.36	577.57	577.58
5085		577.45	577.64	577.65
5125		577.51	577.68	577.69
5165		577.66	577.75	577.76
5205	End of dredging (5890)*	578.13	578.19	578.27
5206	(5891)*	578.14	578.20	578.42
5265	(5950)*	578.24	578.25	578.45
5300	(5985)*	578.27	578.30	578.47
5345	(6030)*	578.30	578.35	578.49
5465	(6150)*	578.31	578.36	578.50
5475	D/S face Dewdney Avenue (6160)*	578.38	578.49	578.61

Table 8 (continued)

Station	Cross-section Location	Flood Events 1:100	1:500	1:500 with floodway
5485	U/S face Dewdney Avenue (6170)*	578.40	578.54	578.62
5500	(6185)*	578.47	578.64	578.71
5850	(6535)*	578.77	578.91	578.93
6105	(6790)*	579.01	579.15	579.16
6395	(7080)*	579.38	579.49	579.49
6425	D/S face N-S grid road (7110)*	579.40	579.51	579.51
6440	U/S face N-S grid road (7125)*	580.90	581.06	581.06
6920	(7605)*	580.91	581.07	581.07
7320	(8005)*	580.92	581.09	581.09
7720	(8405)*	580.97	581.14	581.14
7960	(8645)*	581.06	581.21	581.21
8175	(8860)*	581.32	581.43	581.43
8375	D/S face E-W grid road (9060)*	581.50	581.61	581.61
8386	U/S face E-W grid road (9071)*	582.30	582.40	582.40
8455	(9140)*	582.31	582.41	582.41
8775	(9460)*	582.41	582.52	582.52
8810	D/S face N-S grid road (9495)*	582.45	582.56	582.56

† although the computed values in this table are shown to two decimals to better illustrate the difference in total energy between cross-sections and between flood events, total energy elevations cannot be realistically predicted to this degree of accuracy.

* corresponding station for pre-dredged conditions

As with the pre-dredged conditions, the greatest headlosses occur at the culvert crossings. The north-south grid road creates the largest single headloss of 1.55 m for the 1:500 year flood followed by Assiniboine Avenue, the east-west grid road, and Trusedale Drive with losses of 1.13 m, 0.79 m and 0.50 m respectively.

Comparing dredged and pre-dredged conditions, the total headloss across Assiniboine Avenue increased by 0.29 m and

0.04 m for the 1:100 year and 1:500 year flood respectively despite the dredging since culvert capacities were not increased nor the top of road lowered. From Assiniboine Avenue to the end of the dredging, however, the water surface profiles were reduced by a maximum of 0.74 m at Fleet Street to a minimum of 0.10 m at Highway #33 with a mean of about 0.40 m. The dredging had no effect on the water surface profile upstream of the dredged reaches.

Comparing the 1:500 year design profiles in Table 8, one can see that for most of the reach analyzed, the floodway encroachment results in almost no rise in the water surface profile. This is due, in part, to the backwater effect of the culvert crossings and the floodway encroachment which tend to be in areas of little or no hydraulic conveyance owing to depth criteria considerations. Exceptions to this are at the Cindercrete plant and from the end of the dredging to Dewdney Avenue. However, the rise in the water surface profile is within the criteria of 0.30m.

D. SOUTH STORM CHANNEL

The starting water surface elevation calculated for the model at the confluence with Wascana Creek is 567.0 m for the June 23, 1980 storm peak flow of 3.82 m^3/s. Running the model to Pasqua Street a water surface elevation of 569.03 m was calculated compared to the observed elevation of 568.96 m. Manning's roughness coefficients for the channel and the overbanks were calculated to be 0.035 and 0.042 respectively.

The starting water surface elevation calculated at the confluence for the 1:100 year peak flow of 14 m^3/s is 567.65 m, and for the 1:500 year peak flow of 17 m^3/s is 567.75 m.

Except for the CNR Lewvan Line and a wood car bridge just downstream of Pasqua Street, all the channel crossings are culverts. Culvert capacities are insufficient to pass either the 1:100 year or 1:500 year peak flows. The headlosses from Empress Road through Regina Avenue and the Airport Service Road are severe, totalling 2.97 m and 2.90 m for the 1:100 year and 1:500 year floods respectively, causing all the culvert crossings upstream to be all inundated. Pasqua Street, a major north-south artery, would be inundated to a depth of almost 1.25 m for the 1:500 year peak flow of 17 m^3/s. Other crossings would be inundated to depths ranging from 0.34 m to 0.89 m.

The removal of the CNR trestle had virtually no effect on the hydraulics of the South Storm Channel due to the backwater effects of the culvert crossings downstream.

Table 9 summarizes the water surface profiles for the computed design 1:100 and 1:500 year floods. Figure 9 shows the water surface profiles for the design floods.

Table 9

SOUTH STORM CHANNEL
TOTAL ENERGY ELEVATIONS FOR FLOOD FLOWS

Elevations to Geodetic Datum in metres†

Station	Cross-section Location	Flood Events 1:100	1:500
0	At confluence	567.86	567.96
263		568.47	568.55
487		568.78	568.88
602	D/S face Empress Road	568.98	569.10
645	U/S face Empress Road	569.88	569.91
661		569.88	569.91
677	D/S face Regina Avenue	569.89	569.93
703	U/S face Regina Avenue	570.76	570.98
705		570.76	570.98
759		570.76	570.98
814	D/S face Airport Service Road	570.76	570.99
850	U/S face Airport Service Road	571.96	572.03
926		571.96	572.03
1236		571.96	572.03
1267	D/S face CNR trestle (Lewvan Line)	571.96	572.03
1271	U/S face CNR trestle (Lewvan Line)	571.96	572.03
1288		571.96	572.03
1438		571.96	572.03
1453	D/S face wood car bridge	571.96	572.03
1457	U/S face wood car bridge	571.96	572.03
1497		571.96	572.03
1615	D/S face Pasqua Street	571.96	572.04
1660	U/S face Pasqua Street	571.96	572.04
1751		571.96	572.04
1900	D/S face Hill Avenue	571.96	572.04
1950	U/S face Hill Avenue	571.97	572.04
2080		571.97	572.04
2171	D/S face Queen Street	571.97	572.04
2219	U/S face Queen Street	571.97	572.04
2280		571.97	572.04
2630		571.97	572.04
2691	D/S face Lakeview Avenue	571.97	572.05
2745	U/S face Lakeview Avenue	571.98	572.05
2806		571.98	572.06
3026		571.99	572.06
3087	D/S face 25th Avenue	571.99	572.06
3114	U/S face 25th Avenue	572.00	572.07

Table 9 (continued)

Station	Cross-section Location	Flood Events 1:100	1:500
3175		572.00	572.08
3385		572.00	572.08
3446	D/S face Parliament	572.00	572.08
3502	U/S face Parliament	572.01	572.09
3563		572.01	572.09
3953		572.03	572.11
4014	Rae Street outlet	572.04	572.12

† although the computed values in this table are shown to two decimals to better illustrate the different in total energy between cross-sections and between flood events, total energy elevations cannot be realistically predicted to this degree of accuracy.

E. NORTH STORM CHANNEL

The starting water surface elevation calculated for the model at the confluence with Wascana Creek is 564.35 m for the peak flow of 9.8 m^3/s resulting from the June 23, 1980 storm. Running the model to Courtney Street a water surface elevation of 567.72 m was calculated compared to the observed value of 567.75 m. The North Storm Channel from the confluence to the CN Railway is a natural channel with some heavy weed growth. Thus, the Manning's roughness coefficients were calculated to be 0.050 for the channel and the overbanks. From the CN Railway upstream, the channel is excavated and considerably cleaner, similar to the South Storm Channel. Therefore, upstream of Courtney Street Manning's roughness coefficients of 0.035 and 0.042 were used for the channel and overbanks respectively.

The starting water surface elevation calculated at the confluence for the 1:100 year peak flow of 40 m^3/s is 565.76 m, and 565.97 m for the 1:500 year peak flow of 49.0 m^3/s.

All channel crossings are culverts. Culvert capacities are insufficient to pass either the 1:100 year or 1:500 year peak flows causing water surface elevations to rise until weir flow occurs. The headlosses from Courtney Street through Dorothy Street and the CN Railway crossings are severe, totalling 3.27 m and 3.14 m for the 1:100 year and 1:500 year peak flow, respectively.

Table 10 summarizes the water surface profiles for the computed design 1:100 and 1:500 year for the two conditions: with the Courtney Street crossing in place, and without the Courtney Street crossing (with the new development in the area, the City permanently removed the Courtney Street crossing). Figure 10 shows the water surface profiles for the 1:100 year and 1:500 year design floods without the Courtney Street crossing.

Comparing the results in Table 10, one can see that the major effect of removing Courtney Street is felt between Courtney Street and Dorothy Street. The removal of Courtney Street has no effect upstream of the CN Railway due to the insufficient capacities of the culverts at Dorothy and the CN Railway. By increasing the culvert capacities and/or lowering the Dorothy Street and CN Railway crossings of the North Storm Channel, the design flood levels upstream could be substantially reduced.

Table 11 summarizes the water surface profiles for the Northwest Branch of the North Storm Channel and Figure 11 shows the water surface profiles for the computed design 1:100 year and 1:500 year

Table 10

NORTH STORM CHANNEL
TOTAL ENERGY ELEVATIONS FOR FLOOD FLOWS

Elevations to Geodetic Datum in metrest

Station	Cross-section Location	Flood Events			
		1:100 year		1:500 year	
		With Courtney Street	Without Courtney Street	With Courtney Street	Without Courtney Street
0	At Confluence with Wascana Creek	565.76	565.76	565.97	565.97
110		566.60	566.60	566.73	566.73
500		567.13	567.13	567.26	567.26
860		567.48	567.48	567.59	567.59
900		567.66	567.66	567.76	567.76
1150		568.08	568.08	568.18	568.18
1380		568.36	568.36	568.47	568.47
1425	D/S face Courtney Street	568.55	568.55	568.71	568.71
1440	U/S face Courtney Street	569.97	568.75	570.05	568.93
1485		569.98	568.80	570.05	568.99
1700		569.99	568.88	570.06	569.07
1745	D/S face Dorothy Street	569.99	568.92	570.07	569.11
1785	U/S face Dorothy Street	571.28	571.23	571.34	571.31
1830		571.28	571.23	571.35	571.32
2250		571.30	571.25	571.37	571.34
2295	D/S face CN Railway	571.30	571.25	571.37	571.34
2320	U/S face CN Railway	571.86	571.86	571.90	571.90
2405		571.86	571.86	571.90	571.90
2490	D/S face low level crossing	571.86	571.86	571.90	571.90
2507	U/S face low level crossing	571.86	571.86	571.90	571.90
2552		571.86	571.86	571.90	571.90
2812		571.86	571.86	571.90	571.90
2857	D/S face 7th Avenue North	571.86	571.86	571.90	571.90
2898	U/S face 7th Avenue North	571.86	571.86	571.90	571.90
2943		571.86	571.86	571.90	571.90
3083		571.86	571.86	571.91	571.91

Table 10 (continued)

Station	Cross-section Location	Flood Events 1:100 year With Courtney Street	1:100 year Without Courtney Street	1:500 year With Courtney Street	1:500 year Without Courtney Street
3113	D/S face low level crossing	571.87	571.87	571.91	571.91
3128	U/S face low level crossing	571.87	571.87	571.91	571.91
3158		571.87	571.87	571.91	571.91
3420		571.88	571.88	571.92	571.92
3465	D/S face McCarthy Blvd.	571.88	571.88	571.93	571.93
3537	U/S face McCarthy Blvd.	572.45	572.45	572.50	572.50
3582		572.45	572.45	572.51	572.51
3825		572.46	572.46	572.52	572.52
4125		572.48	572.48	572.54	572.54
4170	D/S face low level crossing	572.48	572.48	572.55	572.55
4187	U/S face low level crossing	572.49	572.49	572.55	572.55
4232		572.49	572.49	572.56	572.56
4382		572.51	572.51	572.58	572.58
4427	D/S face McIntosh Street	572.51	572.51	572.58	572.58
4470	U/S face McIntosh Street	572.52	572.52	572.59	572.59
4515		572.52	572.52	572.59	572.59
4855		572.54	572.54	572.62	572.62
4900	D/S face Arthur Street	572.54	572.54	572.62	572.62
4937	U/S face Arthur Street	572.62	572.62	572.68	572.68
4982		572.63	572.63	572.69	572.69
5122		572.65	572.65	572.71	572.71
5217	U/S of North Branch	572.66	572.66	572.73	572.73
5372		572.68	572.68	572.75	572.75
5417	D/S face Pasqua Street	572.69	572.69	572.77	572.77

† although the computed values in this table are shown to two decimals to better illustrate the difference in total energy between cross-sections and between flood events, total energy elevations cannot be realistically predicted to this degee of accuracy.

Table 11

NORTHWEST BRANCH OF NORTH STORM CHANNEL
TOTAL ENERGY ELEVATIONS FOR FLOOD FLOWS

Elevations to Geodetic Datum in metres†

Station	Cross-section Location	Flood Events 1:100	1:500
0	At confluence	571.25	571.34
35		571.25	571.34
65	D/S face Sherwood Drive	571.25	571.34
110	U/S face Sherwood Drive	571.25	571.34
140		571.25	571.34
310		571.26	571.35
480		571.28	571.37
510	D/S face 9th Avenue North	571.28	571.38
630	U/S face 9th Avenue North	571.86	572.21
660		571.87	572.21
780		571.90	572.23

† although the computed values in this tale are shown to two decimals to better illustrate the difference in total energy between cross-sections and between flood events, total energy elevations cannot be realistically predicted to this degree of accuracy.

floods. The starting elevations of 571.25 and 571.34 m were obtained from the North Storm Channel for the 1:100 year and 1:500 year floods, respectively.

Table 12 summarizes the water surface profiles for the North Branch of the North Storm Channel and Figure 12 illustrates the water surface profiles for the computed design 1:100 year and 1:500 year floods. The starting elevations of 572.65 m and 572.72 m were obtained from the North Storm Channel for the 1:100 year and 1:500 year floods, respectively.

Table 12

NORTH BRANCH OF NORTH STORM CHANNEL
TOTAL ENERGY ELEVATIONS FOR FLOOD FLOWS

Elevations to Geodetic Datum in metres†

Station	Cross-section Location	Flood Events 1:100	1:500
0	At confluence	572.65	572.72
160		572.65	572.72
221	D/S face Sherwood Drive	572.65	572.72
269	U/S face Sherwood Drive	572.80	572.94
294		572.80	572.94
380		572.80	572.95
460		572.80	572.95
490	D/S face Pasqua Street	572.80	572.95
542	U/S face Pasqua Street	572.95	573.17
557		572.95	573.17
605		572.95	573.17
835		572.96	573.17
1065		572.97	573.18
1125	D/S face Argyle Street North	572.97	573.19
1180	U/S face Argyle Street North	573.25	573.55
1240		573.25	573.55
1490		573.26	573.56
1550	D/S face Garnet Street	573.27	573.57
1590	U/S face Garnet Street	573.52	573.90
1650		573.53	573.91
1920		573.56	573.92
1980	Angus Street outlet	573.61	573.95

† although the computed values in this table are shown to two decimals to better illustrate the difference in total energy between cross-sections and between flood events, total energy elevations cannot be realistically predicted to this degree of accuracy.

F. CHUKA CREEK

The starting water surface elevation calculated for calibrating the model was 572.00 m for the peak flow of 4.5 m^3/s recorded in the spring of 1979. Using a Manning's roughness coefficient of 0.090 for the channel and the overbanks a water surface elevation of 572.49 m was calculated for the hydrometric station at Highway #33

compared to the observed value of 572.52 m. The Manning's roughness coefficient is comparable to those outlined by Chow for a minor stream with sluggish and very weedy reaches (Chow, 1959).

The starting water surface elevations for the 1:100 year (12 m^3/s) and the 1:500 (15 m^3/s) floods were calculated to be 572.20 m and 572.25 m, respectively. Since the design floods for Chuka Creek are due to summer rainfall events, the starting elevations were determined assuming normal summer water levels on Wascana Creek.

Table 13 summarizes the water surface profiles and Figure 13 shows the water surface profiles for the computed design 1:100 and 1:500 year floods. The flood hazard area, however, is determined by the backwater of the 1:500 year flood on Wascana Creek.

Table 13

CHUKA CREEK
TOTAL ENERGY ELEVATIONS FOR FLOOD FLOWS

Elevations to Geodetic Datum in metres†

Station	Cross-section Location	Flood Events 1:100	1:500
0	450 metres U/S of confluence	572.20	572.25
210		572.33	572.39
300		572.38	572.44
450		572.49	572.55
670		572.62	572.68
890		572.74	572.81
900	D/S face Highway #33	572.82	572.91
914	U/S face Highway #33	572.82	572.91
925		572.89	573.00
941	D/S face abandoned RR crossing	572.90	573.01

† although the computed values in this table are shown to two decimals to better illustrate the difference in total energy between cross-sections and between flood events, total energy elevations cannot be realistically predicted to this degree of accuracy.

G. FLOOD HAZARD MAPS

Beside the results described above, the final results of this study also include 1:2000 scale flood hazard maps. These maps show the historic and design floodlines as well as the two zone delineation of the floodway and flood hazard area. Because of their large scale, these maps do not constitute a part of this report, but are kept by the Land Protection Branch of Saskatchewan Environment.

V

CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

1. The HEC II model simulated the flows on Wascana Creek, Pilot Butte Creek, Chuka Creek and the North and South Storm Channels in an acceptable manner as shown by the calibration results. Except for culvert flows, which were calculated by hand, the HEC II model simulated flows at structures such as weirs and bridges under various flow conditions. For the lower frequency floods, the overbank distances had no affect on the computed water surface profiles.
2. The HEC II model is a valuable tool in flood plain management to evaluate floodway encroachments and to delineate flood hazard zones. Method's 4 and 6 of the Flood Plain Encroachment Option Subroutine were found to be most suitable for determining the encroachments producing a 30 cm rise. At structures where weir flow occurs and in reaches where dyking exists, method 1 of the Flood Plain Encroachment Option Subroutine is the most suitable.
3. Culvert capacities in the storm channel crossings are too small to handle the computed design 1:100 year and 1:500 year floods, causing the flows to back up until weir flow occurs. The flood hazard areas in the storm channels could be reduced significantly by increasing the culvert capacities and/or lowering the road grades.

4. Existing dykes at Mount Royal and Riverside were considered to be a means of flood protection for the purposes of delineating the floodway. However, for the computed design 1:500 year flood they are overtopped from Dewdney Avenue to 8th Avenue and at Elphinstone Street, respectively.

5. Table 14 compares the results of this present study to the results of the 1974 report "Wascana Creek Flood Study," completed for the Qu'Appelle Basin Study Board (Qu'Appelle Basin Study Board, 1974). The differences in elevations are due to the following reasons:

    1. The 1974 study used a 1:500 year flow of 156 m^3/s compared to 180 m^3/s for the present study.
    2. The elevations of the present study reflect present floodplain conditions under floodway conditions.
    3. The present study used the HEC II model for calculating the water surface elevations. The 1974 report does not mention the use of a specific backwater model, however, from Appendix 2 of the Wascana Creek Flood Study (Appendix 2, Qu'Appelle Basin Study Board, 1974) it is obvious a backwater model was used. The earlier model, however, does not appear to be as sophisticated as the HEC II.

    The present study, given the detailed topographic mapping and updated hydrology, is considered to be the more accurate of the two studies, representing most accurately existing conditions.

Table 14

COMPARISON OF 1:500 YEAR FLOOD LEVELS
WITH 1974 WASCANA CREEK FLOOD STUDY

Elevations to Geodetic Datum in metres

Reach	Description	Flood level (m) 1974*	Present**
1	Richardson to Wascana Golf Course		
	Hunter Creek to E-W Grid Road	573.63	574.12
	Section 1-17-19-2	573.33	573.99
	Section 2-17-19-2	573.02	573.91
	Sections 3 and 10-17-19-2	572.87	573.87
2	Wascana Golf Course to Albert Street		
	Wascana Golf Course to Hwy #1 Bypass	572.72	573.81
	#1 Bypass to Broad Street	572.41	573.51
	Broad Street to Albert Street	572.11	573.00
3	Albert Street to Elphinstone Street	571.35	571.11
4	Elphinstone Street to Lewvan Line	570.43	570.68
5	Lewvan Line to CPR bridge	569.98	570.26
6	CPR bridge to Dewdney Avenue	569.52	569.74
7	Dewdney Avenue to Courtney Street		
	Dewdney Ave. to Dieppe Place School	568.91	568.99
	Dieppe Place School to Courtney St.	568.60	568.43
8	Courtney Street to Sewage Lagoons		
	Courtney Street to Ritter Avenue	568.45	568.17
	Ritter Avenue to CNR	567.99	567.92
	E 1/2 33-19-20-W2	567.39	567.39
	W 1/2 33-19-20-W2	566.93	566.92
	E 1/2 32-19-20-W2	566.17	566.43
	W 1/2 32-19-20-W2	565.71	566.00

* The flood levels were based on the assumption that proposed dyking systems and Albert Street weir modifications would be constructed as recommended in the 1974 Wascana Creek Flood Study. The elevations shown are representative of the reach and were selected for ease of administering the plan proposed in the 1974 Wascana Creek Flood Study.

** The flood levels are the average of the upstream and downstream water surface elevations of the reach, under floodway conditions for the present existing conditions.

B. RECOMMENDATIONS

1. Flood flows greater than or equal to the 1:5 event should be monitored closely on Wascana Creek, Pilot Butte Creek, Chuka Creek and the storm channels, to provide water surface profiles and headloss measurements at all hydraulic structures.
2. The hydraulic efficiencies of all culvert crossings should be increased to reduce the flood hazard areas on the Storm Channels.
3. The existing dyking at Mount Royal and Riverside should receive further specific examination. Both dykes would fail at the design flows. Furthermore, consideration should be given to the degree of dyke inspection and the level of maintenance. Long-term land use plans by the City behind these structures should also be assessed.
4. Any proposed topographical and structural changes in the floodplain should be reviewed by the Saskatchewan Department of Environment prior to construction to determine the impact of the proposed construction on the flood hazard area.
5. The hydraulic models for Wascana Creek and its tributaries should be updated regularly to include additional topographical and structural changes in the floodplain.

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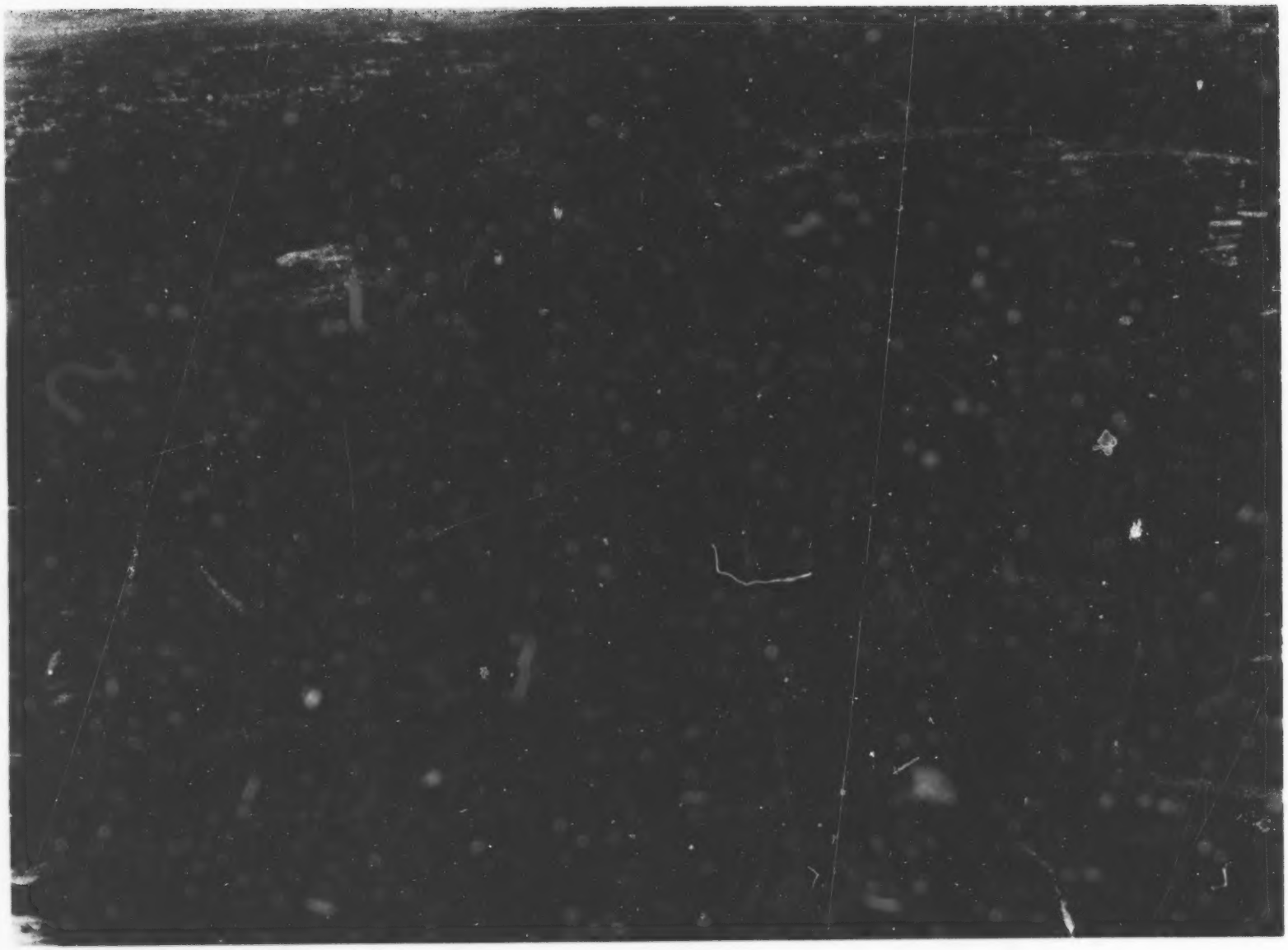
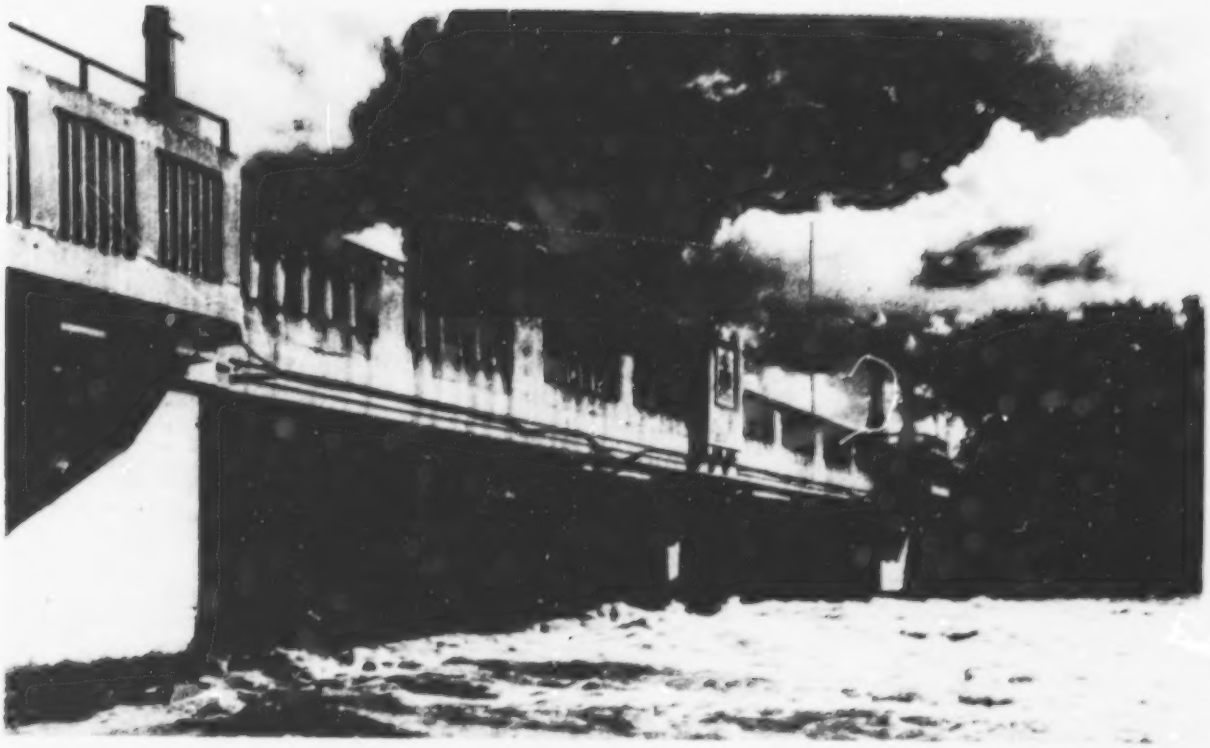
Wyngaarden, N., 1980, "Flood Peak Potential Regina Storm Channels," Report No. HYD-5-50, Hydrology Branch, Saskatchewan Environment.

PHOTOS



Wascana Lake, April, 1974

Wascana Creek below Albert Street, April, 1974

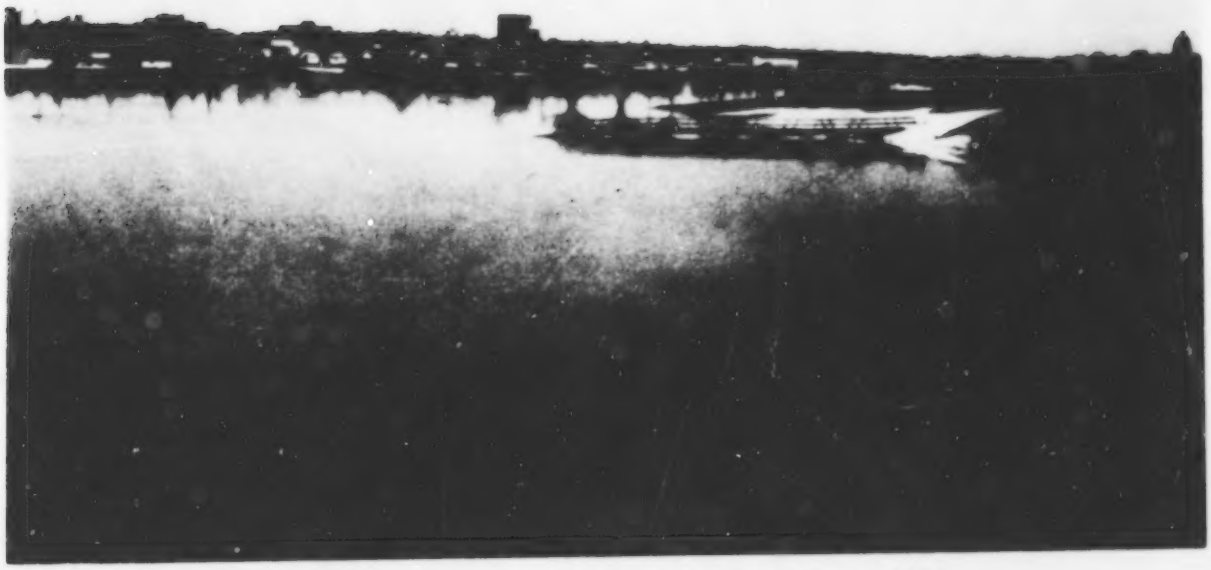


Top: Albert Street Weir Discharge, April, 1982 (courtesy of G. Denker)

Bottom: Wascana Creek at Rotary Park, April, 1982 (courtesy of G. Denker)

Nascana Creek Flooding at Cameron Street and 18th Avenue, April, 1971
(courtesy of R. Ancal)

Wascana Creek at the Coronation Street Footbridge, April, 1979 (courtesy of D. Mercer)

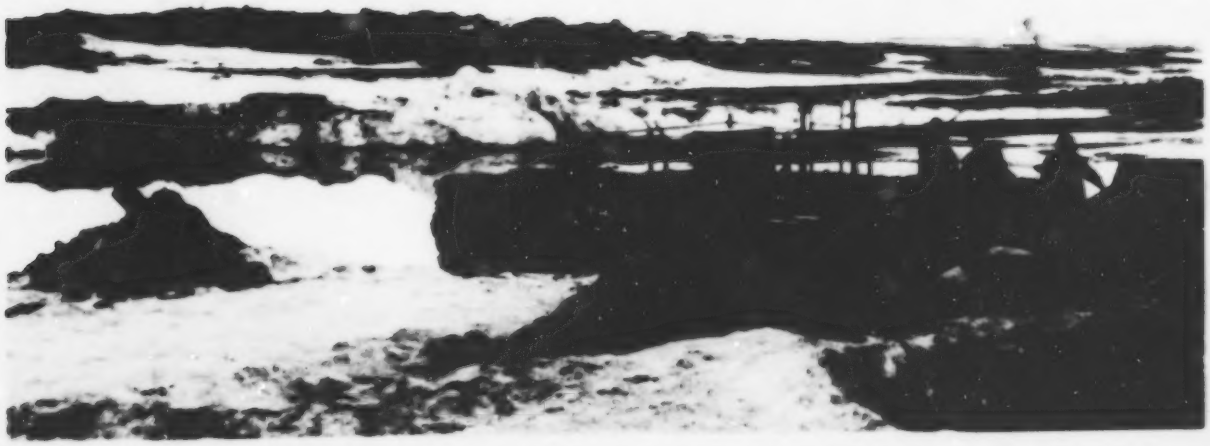


Top: Wascana Creek Upstream of Elphinstone Street, April, 1974

Bottom: Wascana Creek at Craig Golf Course, April, 1982

Top: Wascana Creek at the new 13th Avenue Bridge, April, 1982 (courtesy G. Denker)

Bottom: Wascana Creek at 11th Avenue, April, 1982



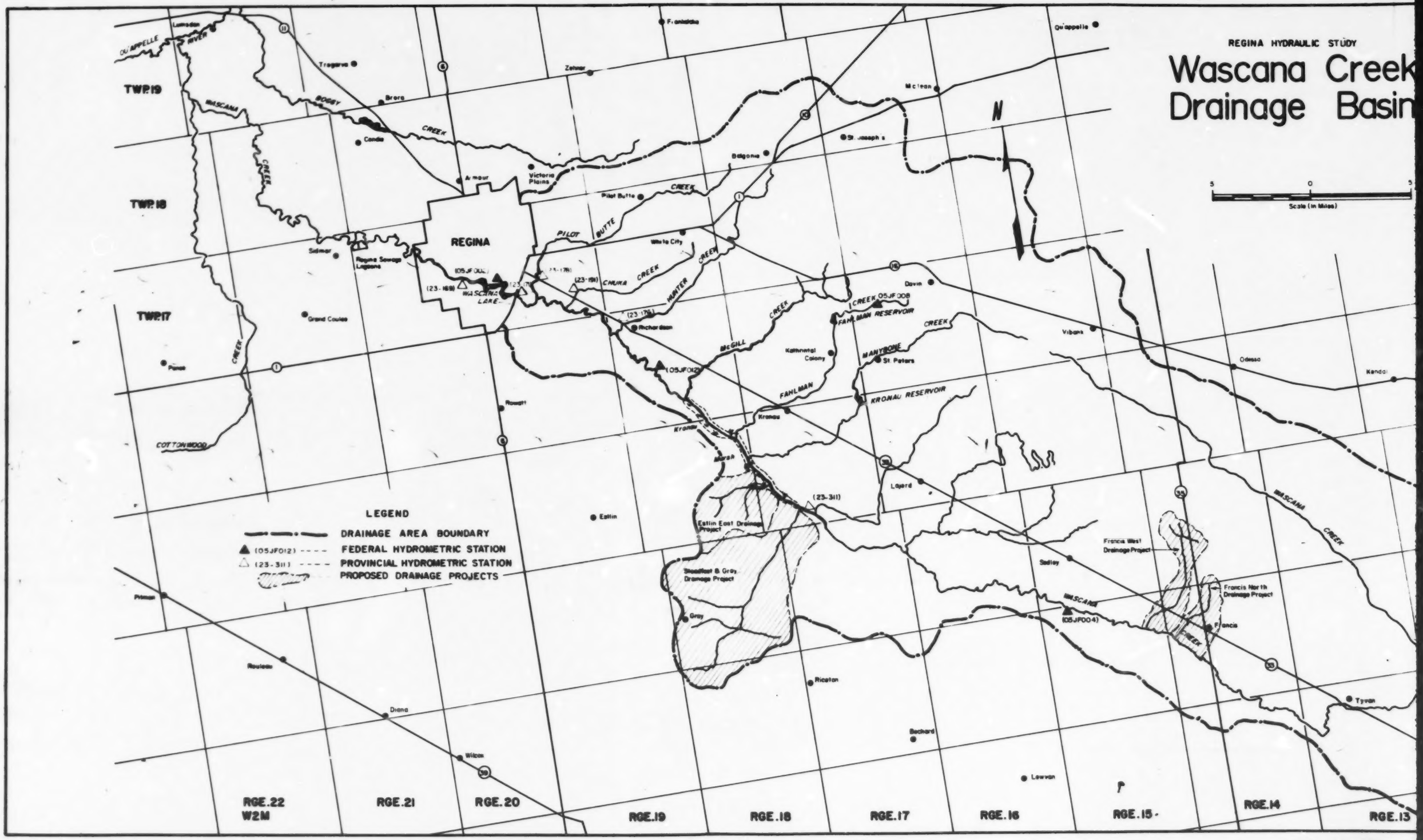
Top: Wascana Creek at McCarthy Blvd. Bridge, April, 1982 (courtesy G. Denker)

Bottom: North Storm Channel, Normanview West, April, 1982

FIGURES

REGINA HYDRAULIC STUDY

Wascana Creek Drainage Basin



REGINA HYDRAULIC STUDY

Wascana Creek Drainage Basin

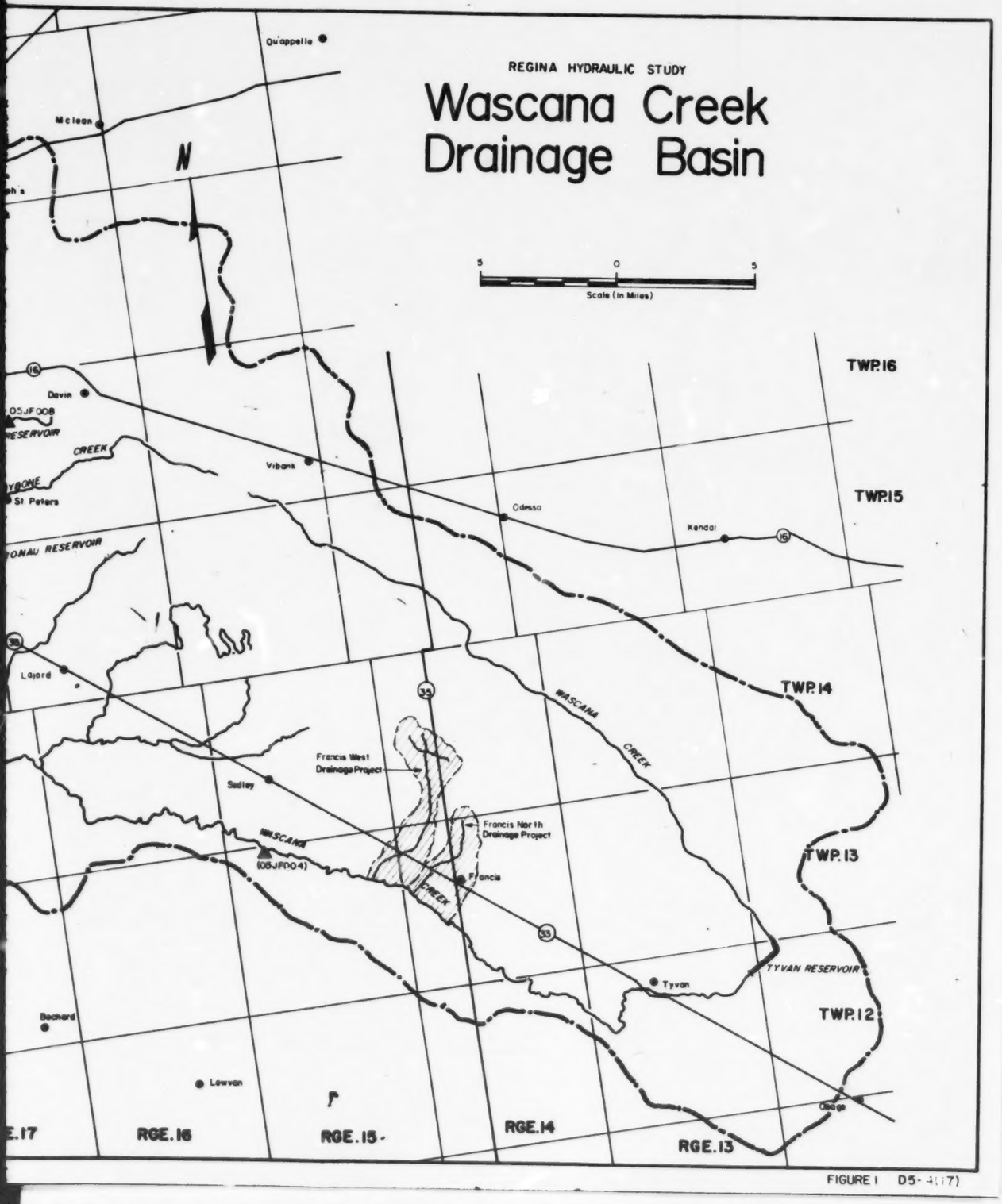
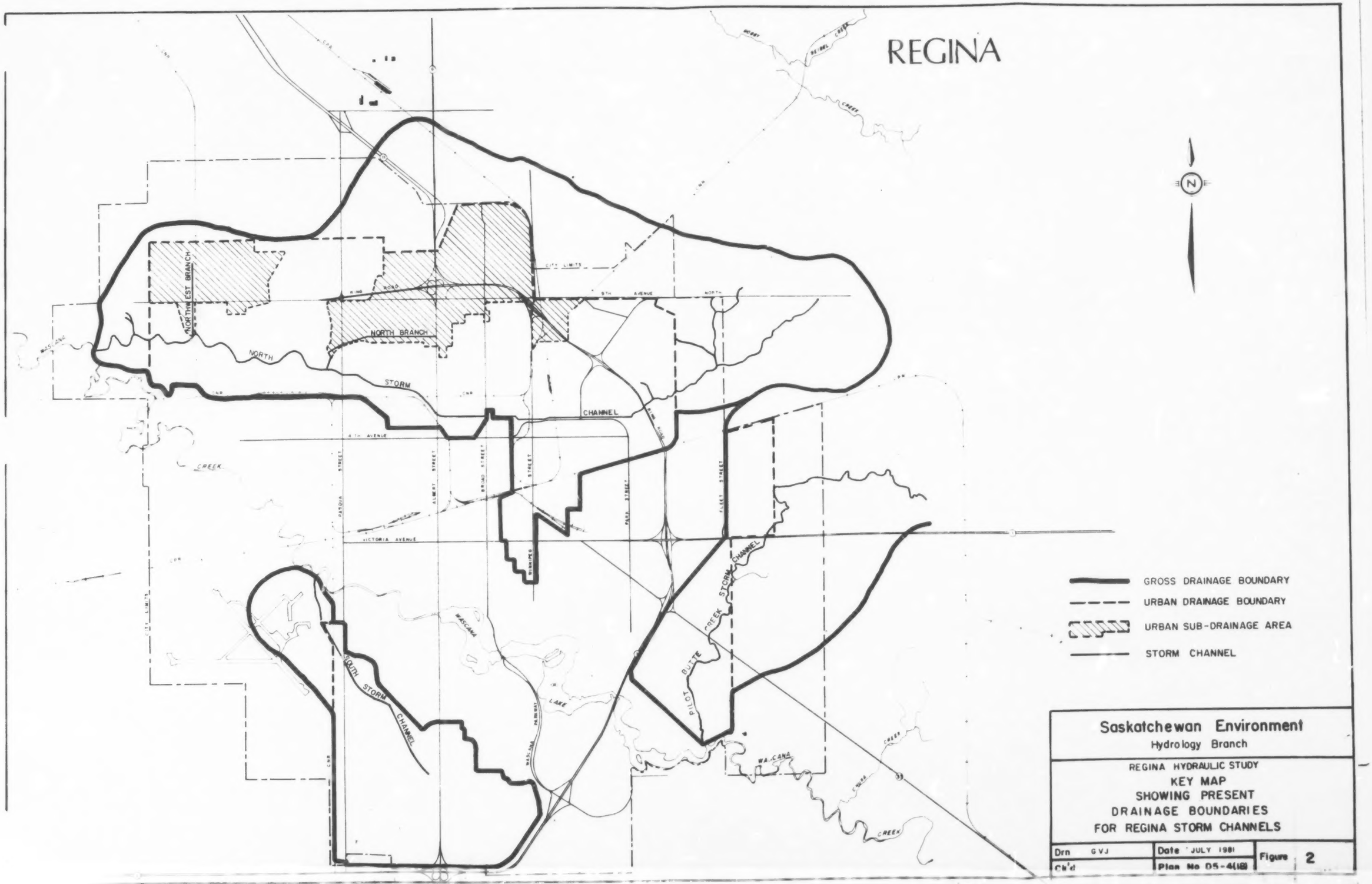


FIGURE 1 D5-4(17)



Saskatchewan Environment
Hydrology Branch

REGINA HYDRAULIC STUDY
KEY MAP
SHOWING PRESENT
DRAINAGE BOUNDARIES
FOR REGINA STORM CHANNELS

Drn GVJ	Date JULY 1981	Figure 2
Ch'd	Plan No 05-4188	

5220
5920

5180
5910

5200
5910

5220
5910

5240
5910

5260
5910

5200
5900

5220
5900

5200
5890

5220
5890

5240
5890

5320
5890

5340
5890

5220
5880

5240
5880

5320
5880

5340
5880

5240
5870

5260
5870

REGINA

5300
5870

5320
5870

5240
5860

5260
5860

5280
5860

5300
5860

5320
5860

5240
5850

5260
5850

5280
5850

5300
5850

5320
5850

5340
5850

5260
5840

5300
5840

5320
5840

5340
5840

5360
5840

5300
5830

5320
5830

5340
5830

5300
5820

5320
5820

5340
5820

5360
5820

5360
5810

TWP 16

RGE 20

RGE 19 W 2 M

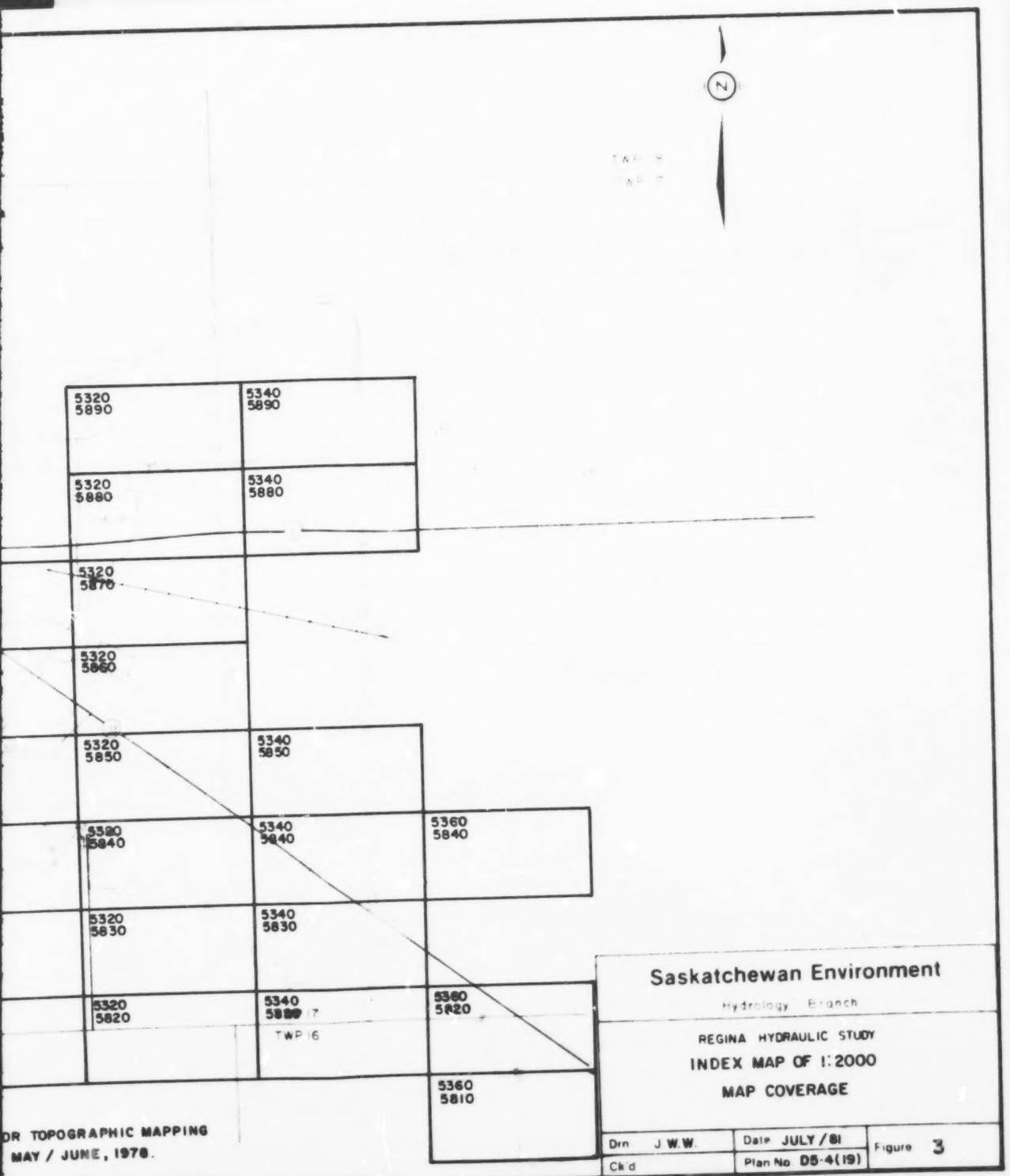
NOTE : AIRPHOTOS FOR TOPOGRAPHIC MAPPING
WERE TAKEN MAY / JUNE, 1978.

Saskatch

REGINA
INDEX
MAP

Drn J.W.W.

Ck'd



OR TOPOGRAPHIC MAPPING
MAY / JUNE, 1978.

Saskatchewan Environment

Hydrology Branch

REGINA HYDRAULIC STUDY

INDEX MAP OF 1:2000

MAP COVERAGE

Drn J.W.W.	Date JULY / 81	Figure 3
Ck'd	Plan No. DS-4(19)	

REGINA

RGE 20

RGE 19 W 2 M

TWP 17

TWP 16

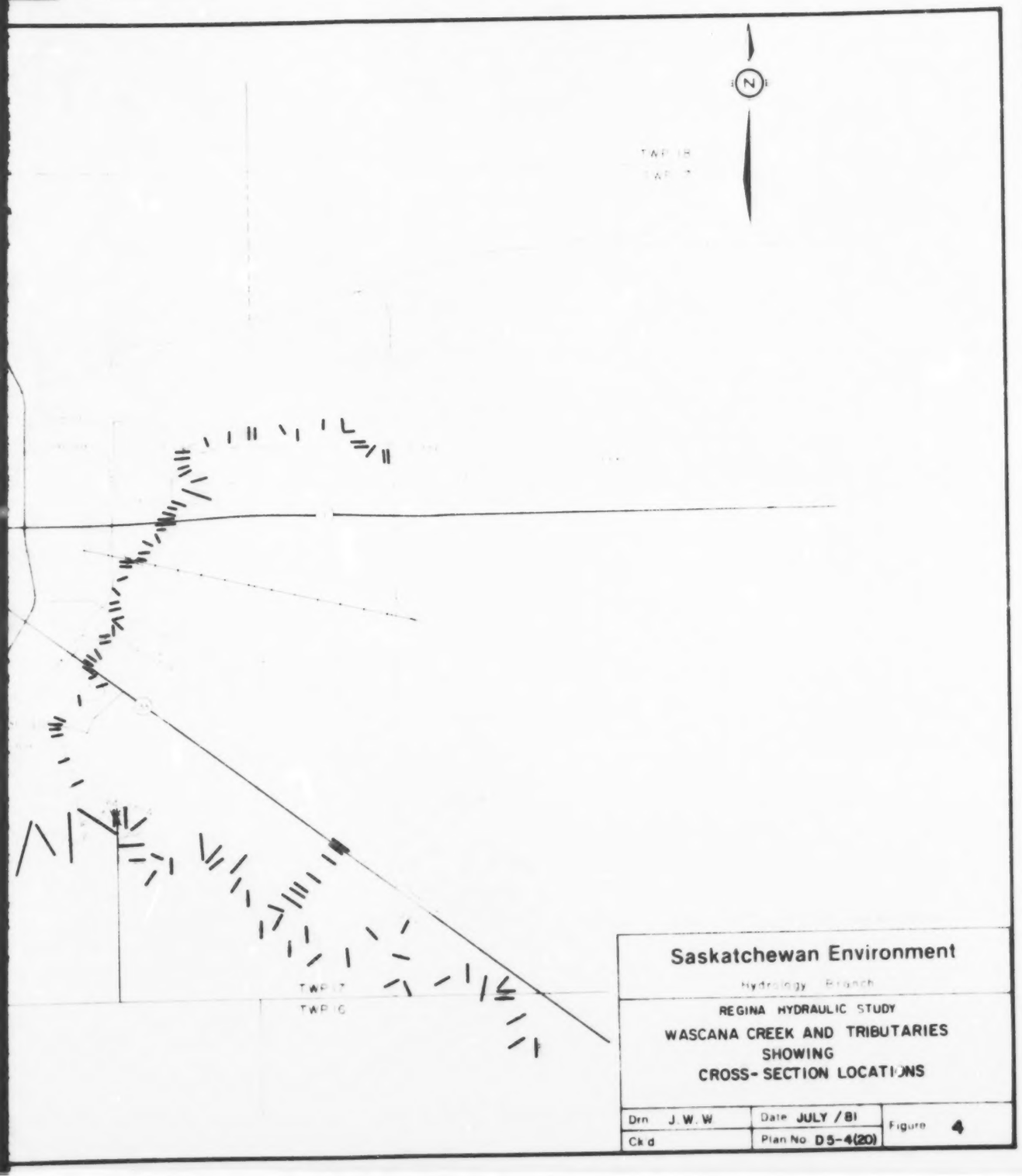
Saska

WASCAN

CRO

Drn J. W. W

Ck'd



Saskatchewan Environment

Hydrology Branch

REGINA HYDRAULIC STUDY

WASCANA CREEK AND TRIBUTARIES
SHOWING
CROSS-SECTION LOCATIONS

Drn J.W.W	Date JULY / 81	Figure 4
Ck'd	Plan No D5-4(20)	

SEWAGE LAGOONS

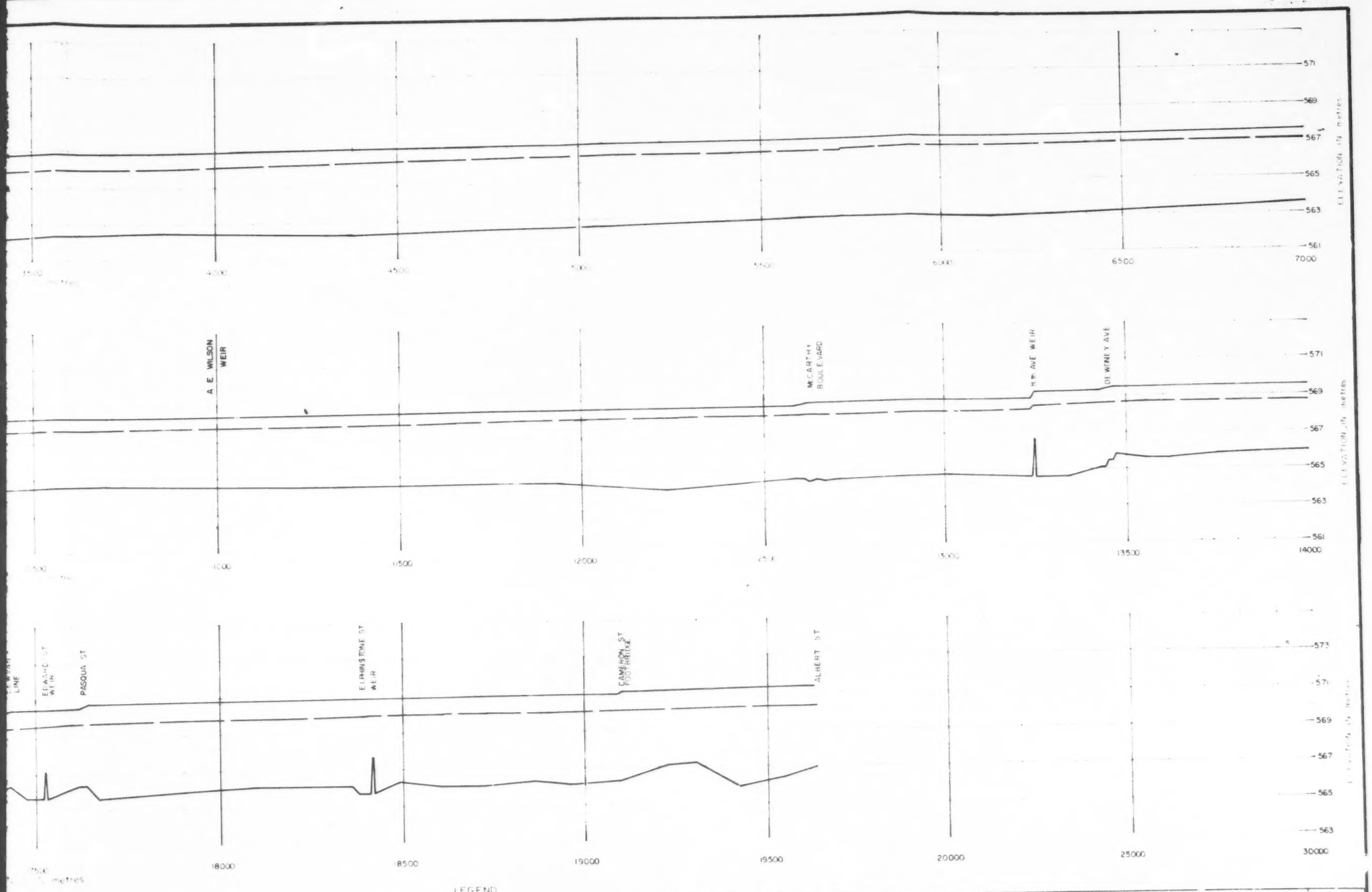
OHIO ROAD

A. E. WILSON WEIR

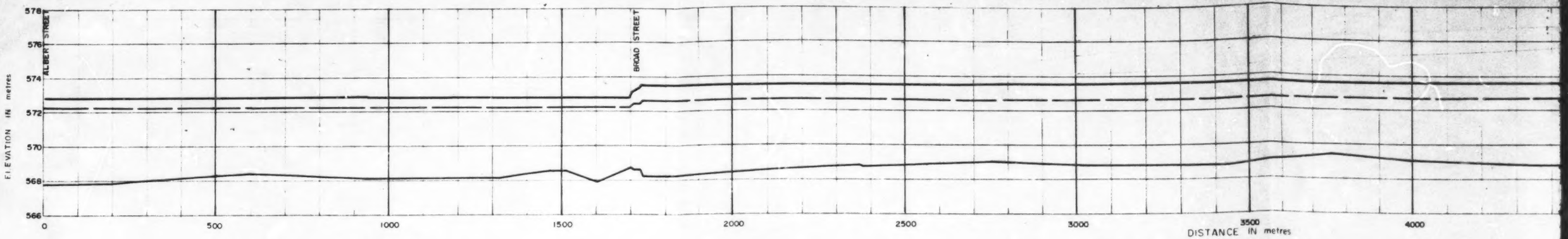
LEAVAN LINE

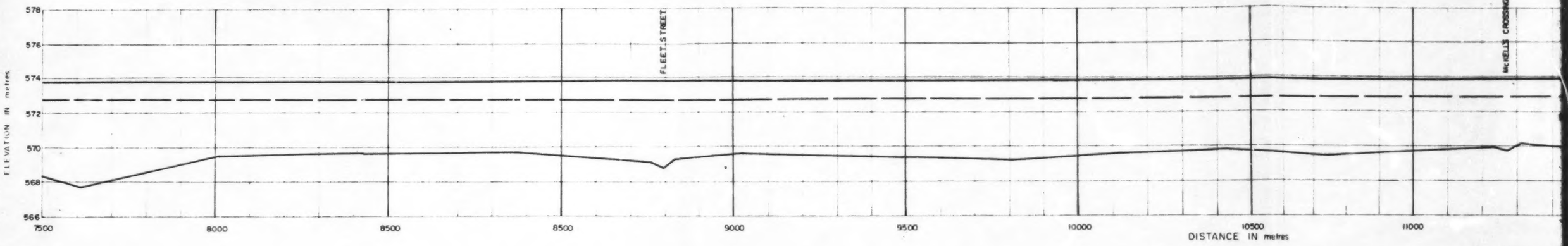
EDWARD ST WEIR

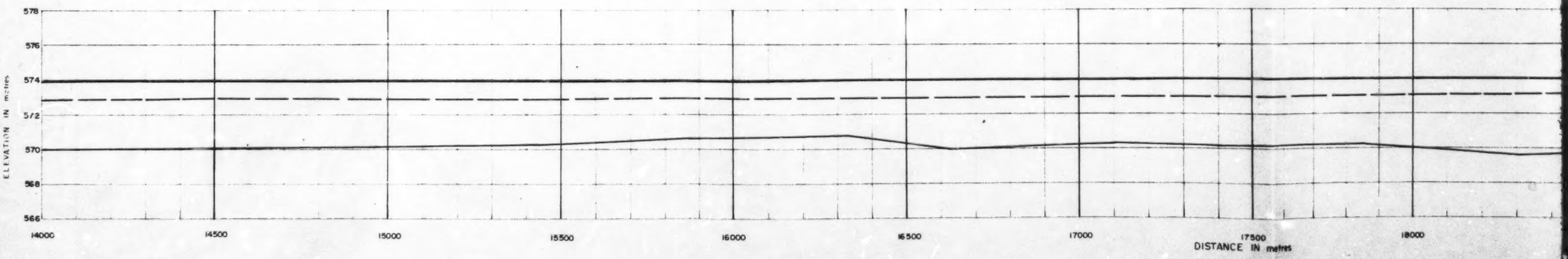
PASQUA ST



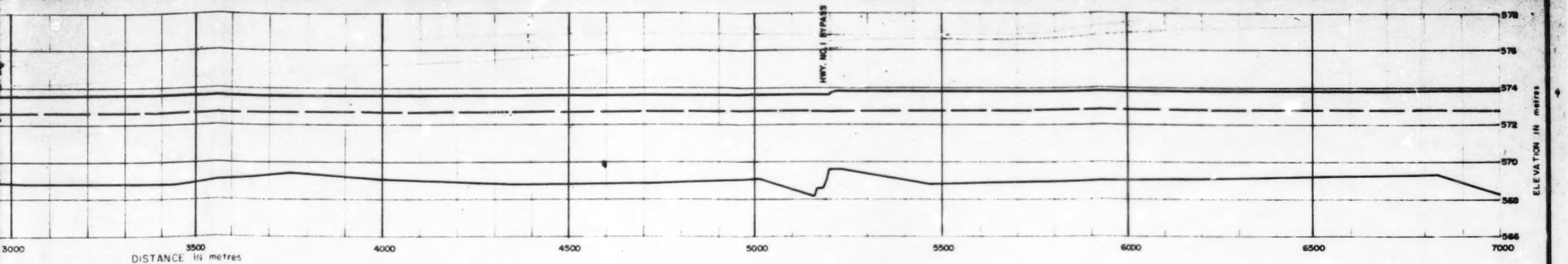
Saskatchewan Environment Hydrology Branch		REGINA HYDRAULIC STUDY WASCANA CREEK SEWAGE LAGOONS TO ALBERT STREET 1974 AND 1:500 YEAR FLOOD PROFILES	Figure 5
Drn G.V.J.	Date JULY 1981		
Ck'd	Plan No. D5-4(21)		

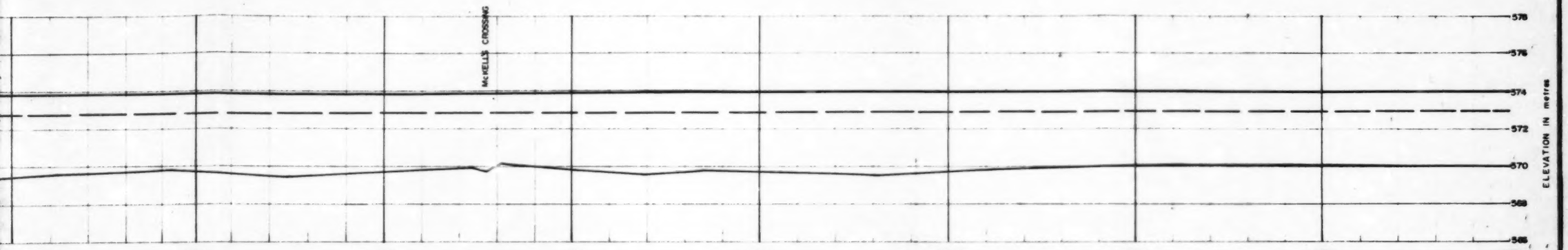

ALBERT STREET
BROAD STREET
ELEVATION IN metres
578
576
574
572
570
568
566
0
500
1000
1500
2000
2500
3000
3500
4000
DISTANCE IN metres

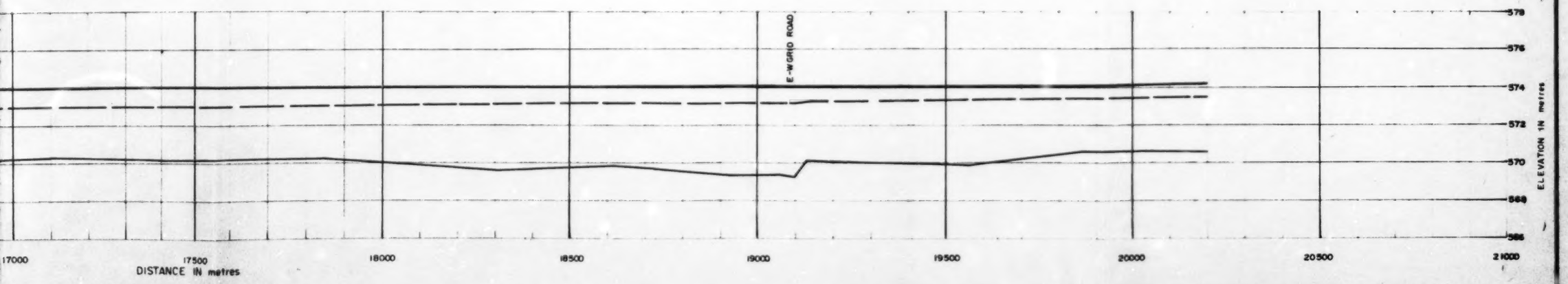

FLEET STREET
McNEILS CROSSING
ELEVATION IN metres
578
576
574
572
570
568
566
7500
8000
8500
8500
9000
9500
10000
10500
11000
DISTANCE IN metres


ELEVATION IN metres
578
576
574
572
570
568
566
14000
14500
15000
15500
16000
16500
17000
17500
18000
DISTANCE IN metres

– 1:50
– 1974
– CHA



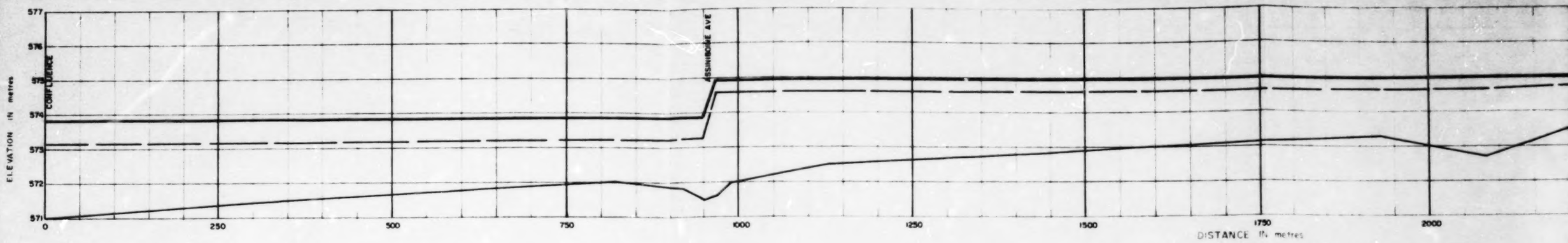


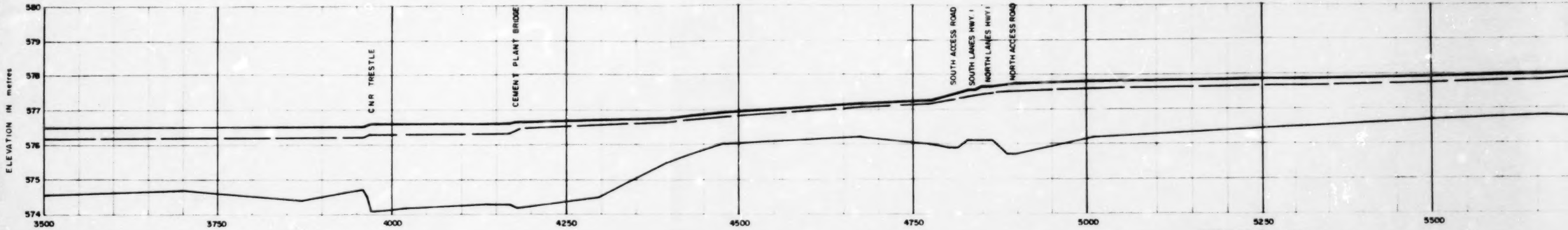


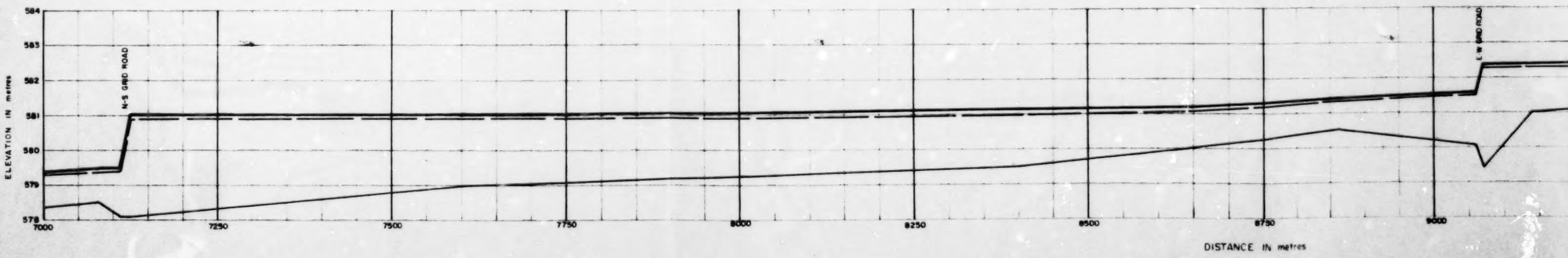
LEGEND

- 1:500 YEAR FLOOD W/ FLOODWAY PROFILE
- 1974 FLOOD PROFILE
- CHANNEL INVERT

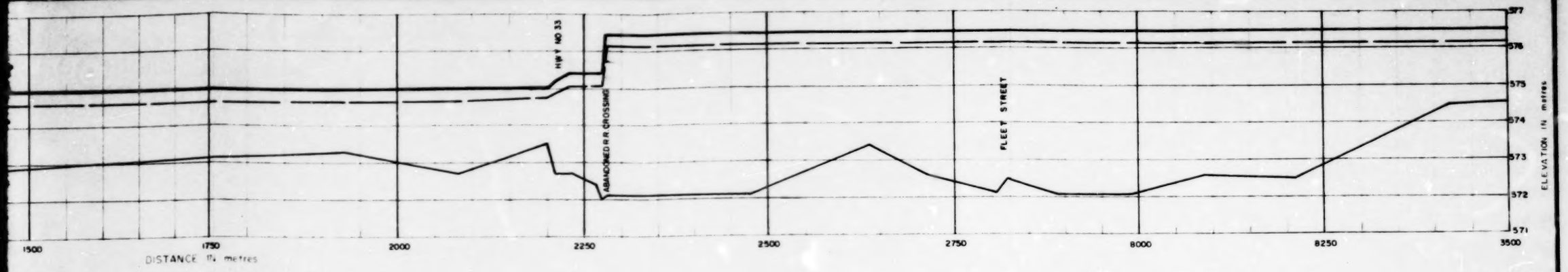
Saskatchewan Environment Hydrology Branch		REGINA HYDRAULIC STUDY WASCANA CREEK ALBERT STREET TO RICHARDSON 1974 AND 1:500 YEAR FLOOD PROFILES	Figure
Drn GVJ	Date JULY 1981		6
Ck'd	Plan No. D5-4(22)		

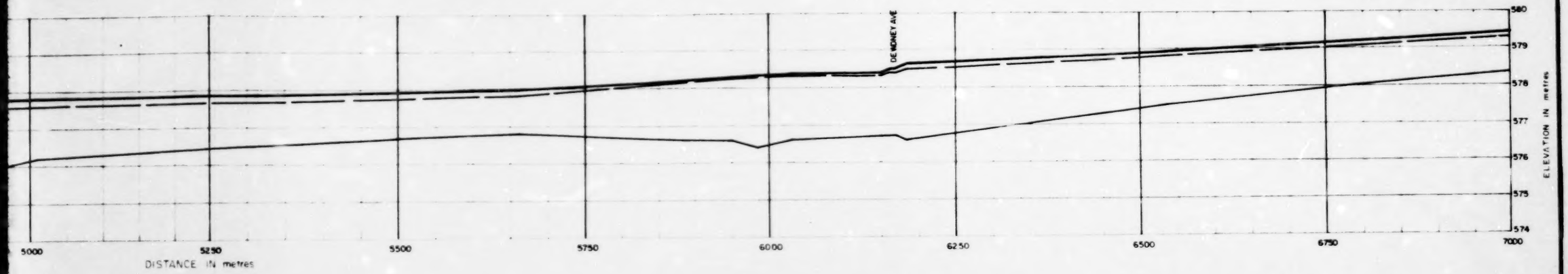

ELEVATION IN metres
577
576
575
574
573
572
571
CONFLUENCE
ASSINIBOINE AVE
0
250
500
750
1000
1250
1500
1750
2000
DISTANCE IN metres

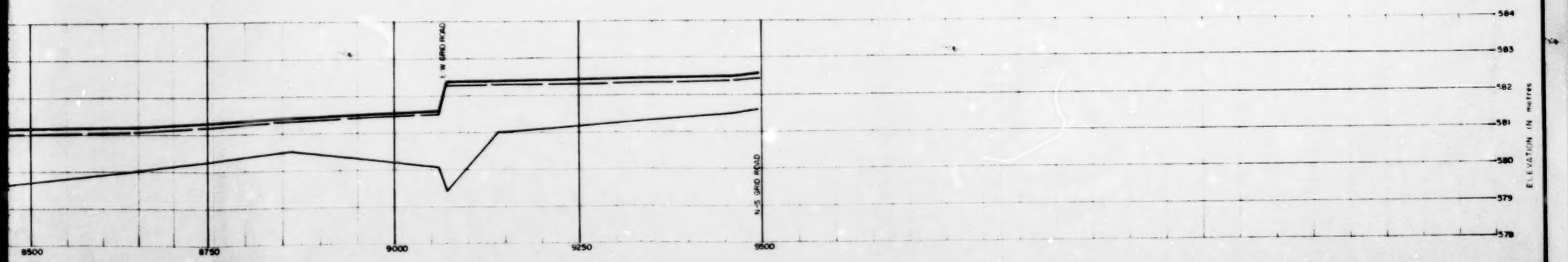

ELEVATION IN metres
580
579
578
577
576
575
574
C.N.R. TRESTLE
CEMENT PLANT BRIDGE
SOUTH ACCESS ROAD
SOUTH LANES HWY 1
NORTH LANES HWY 1
NORTH ACCESS ROAD
3500
3750
4000
4250
4500
4750
5000
5250
5500
DISTANCE IN metres


ELEVATION IN metres
584
583
582
581
580
579
578
N-S GRID ROAD
E-W GRID ROAD
7000
7250
7500
7750
8000
8250
8500
8750
9000
DISTANCE IN metres

Z-04-A1-11



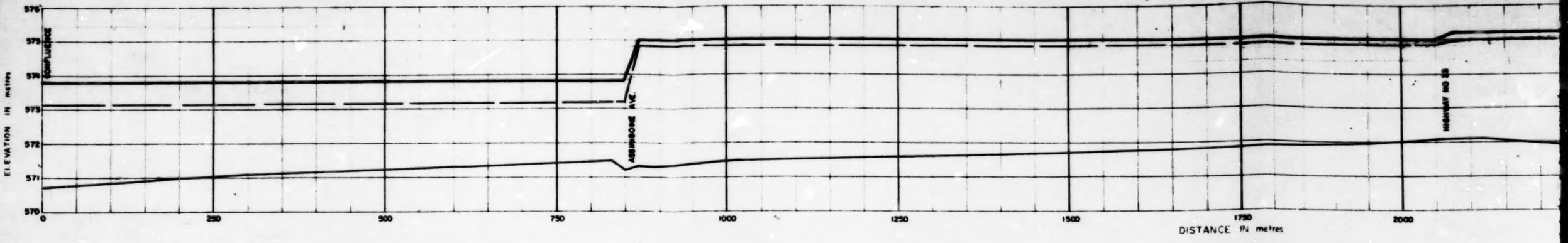


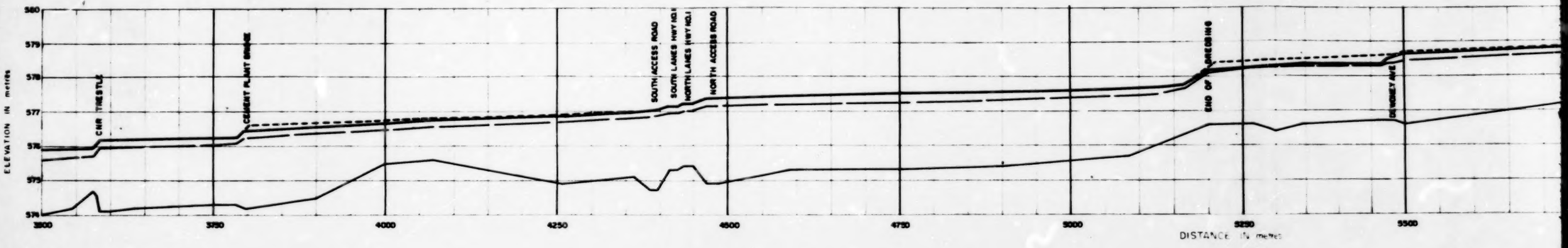


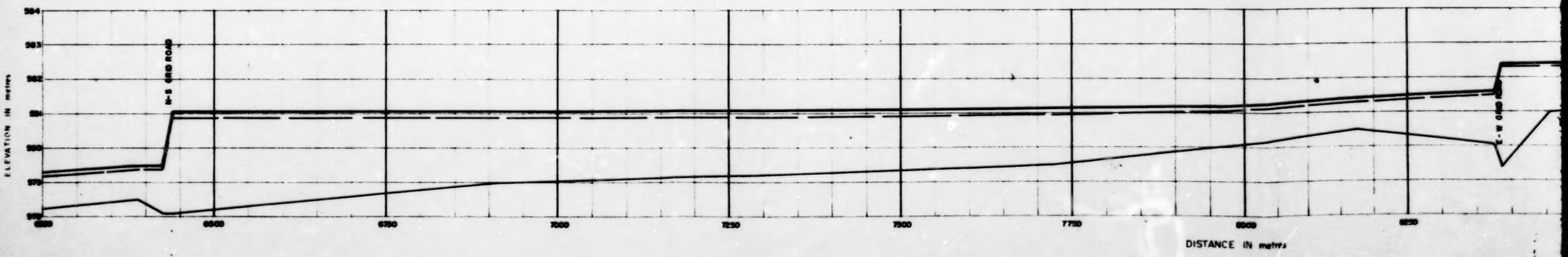
LEGEND

1:500 YEAR FLOOD PROFILE
1:100 YEAR FLOOD PROFILE
CHANNEL INVERT

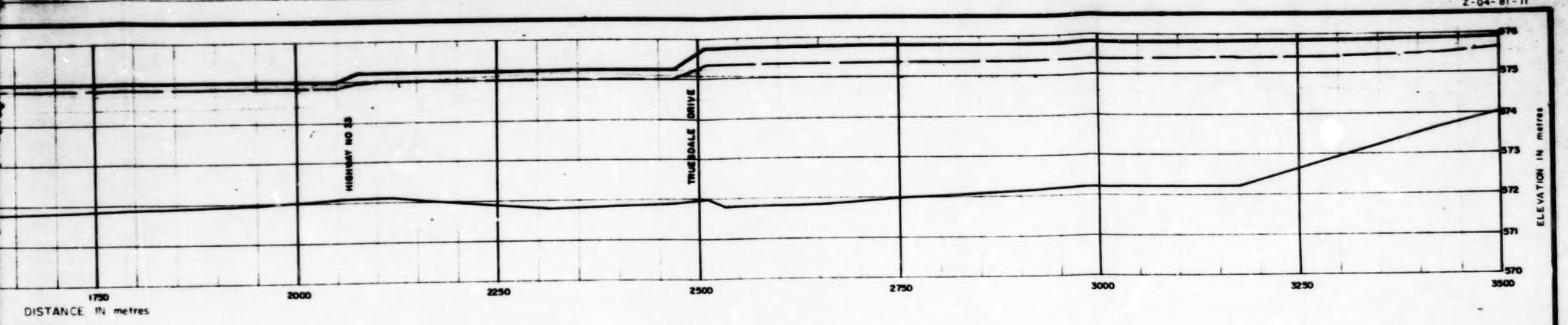
Saskatchewan Environment Hydrology Branch		REGINA HYDRAULIC STUDY PILOT BUTTE CREEK- PRE-DREDGED 1:100 AND 1:500 YEAR FLOOD PROFILES	Figure 7
Drn G.V.J	Date JULY 1981		
Ch'd	Plan No. 05-4(23)		

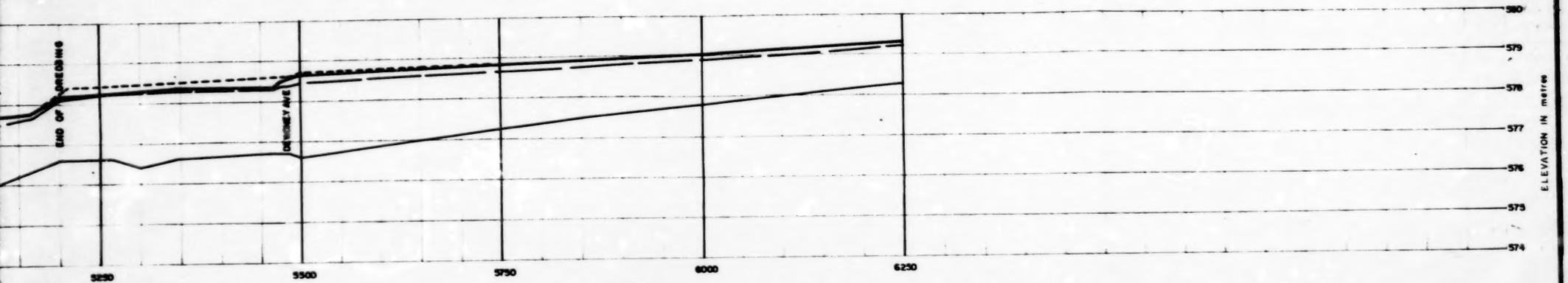

ELEVATION IN metres
570
571
572
573
574
575
0
250
500
750
1000
1250
1500
1750
2000
DISTANCE IN metres
CONFLUENCE
ABERMORE AVE.
HIGHWAY NO 28

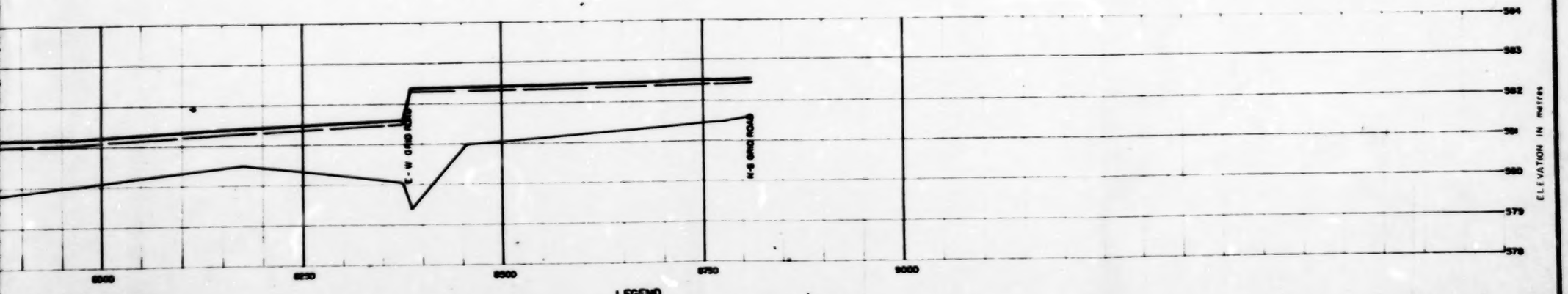

ELEVATION IN metres
576
577
578
579
580
3500
3750
4000
4250
4500
4750
5000
5250
5500
DISTANCE IN metres
CNR TRESTLE
CEMENT PLANT BRIDGE
SOUTH ACCESS ROAD
SOUTH LANES HWY NO.1
NORTH LANES HWY NO.1
NORTH ACCESS ROAD
END OF
DEVONEY AVE


ELEVATION IN metres
582
583
584
6500
6750
7000
7250
7500
7750
8000
8250
DISTANCE IN metres
N-S GRID ROAD
END N-S

Z-04-81-11



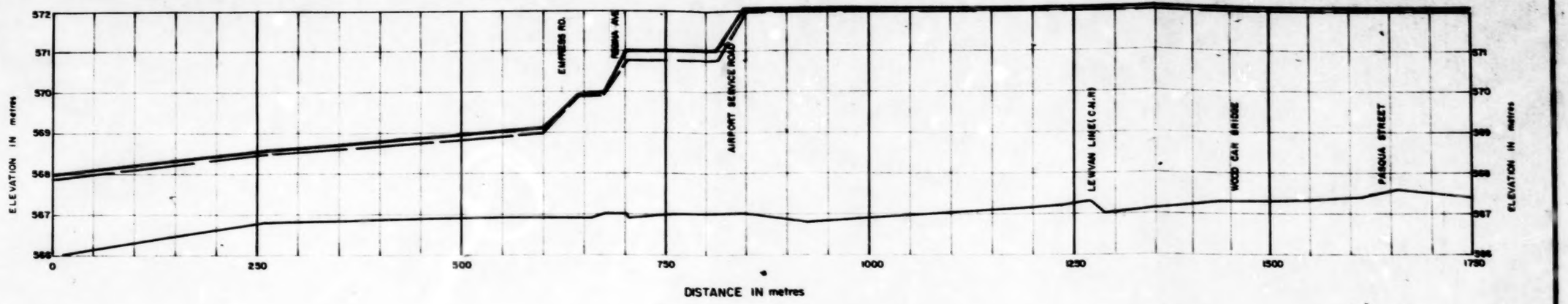


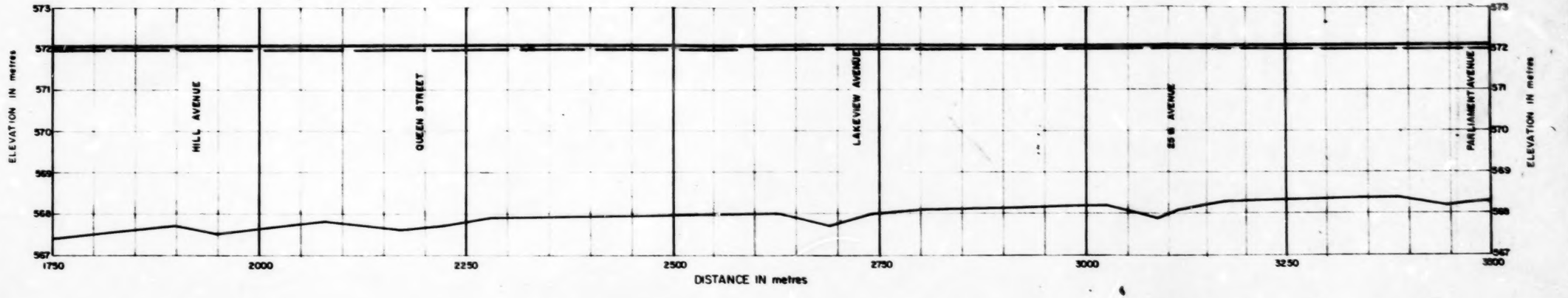


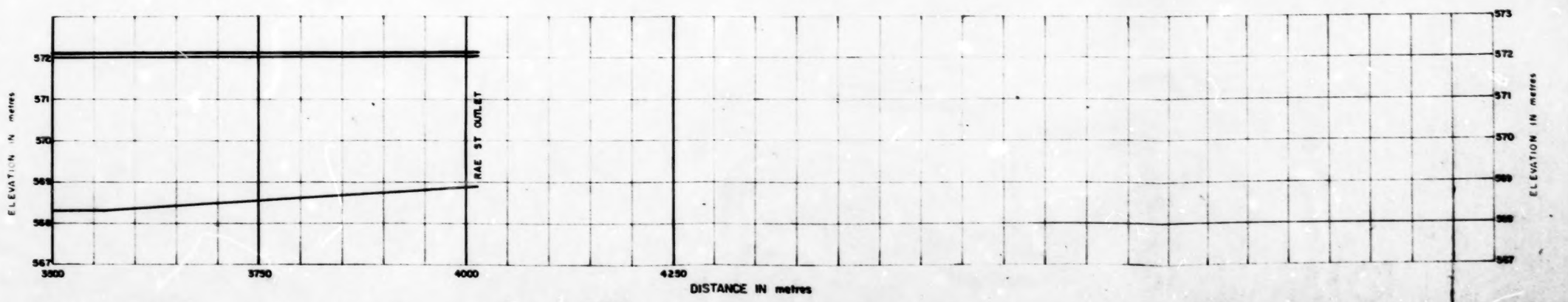
LEGEND

- 1:500 YEAR FLOOD WITH W/ FLOODWAY PROFILE
- 1:500 YEAR FLOOD PROFILE
- 1:100 YEAR FLOOD PROFILE
- CHANNEL INVERT

Saskatchewan Environment Hydrology Branch	REGINA HYDRAULIC STUDY PILOT BUTTE CREEK - DREDGED 1:100 AND 1:500 YEAR FLOOD PROFILES	Figure 8
Drn G V J Ch'd	Date JULY 1981 Plan No. 05-4(24)	







LEGEND
- 1:500 YEAR FLOOD PROFILE
- 1:100 YEAR FLOOD PROFILE
- CHANNEL INVERT

Saskatchewan Environment
Hydrology Branch

Drn O V J	Date JULY 1988
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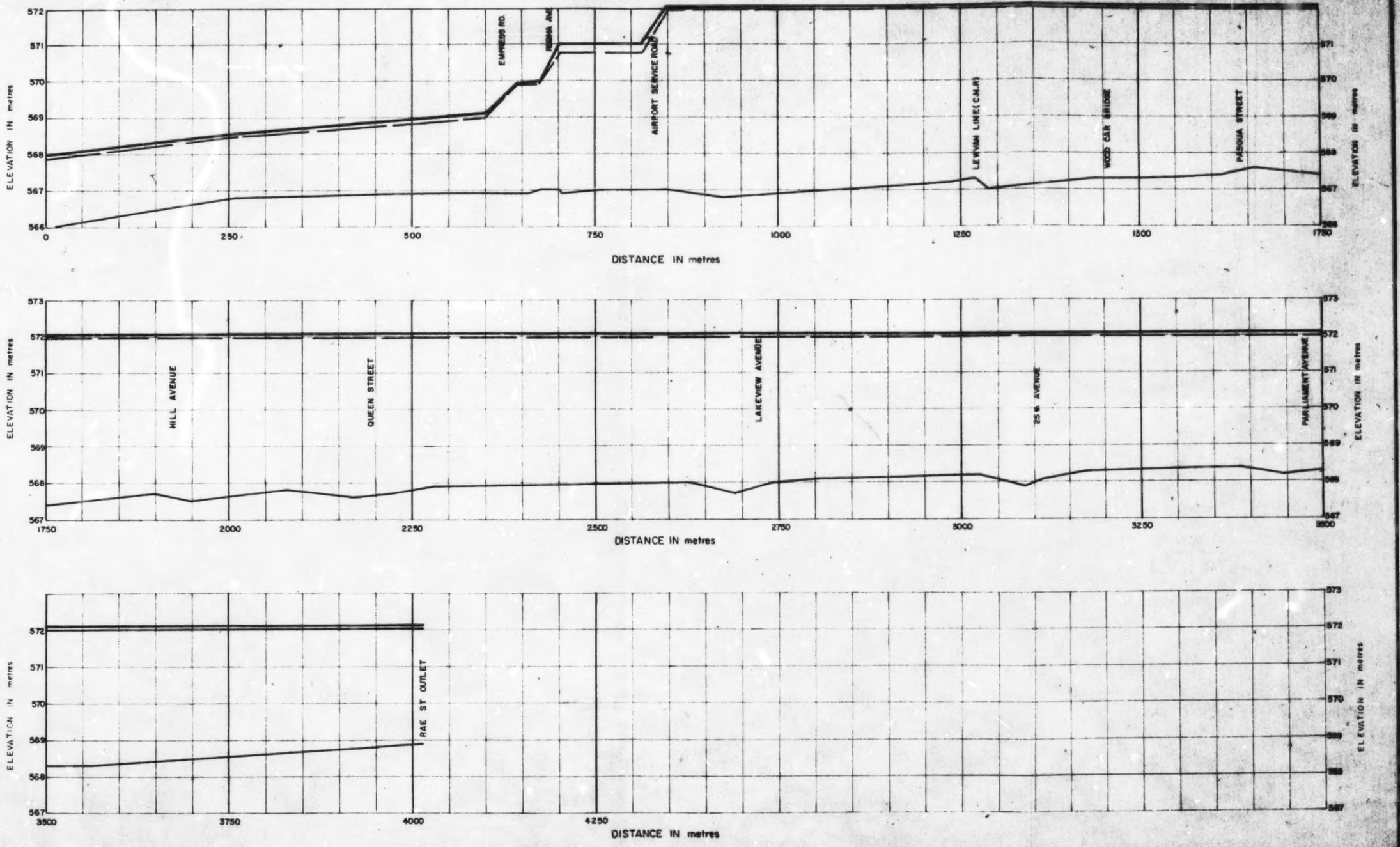
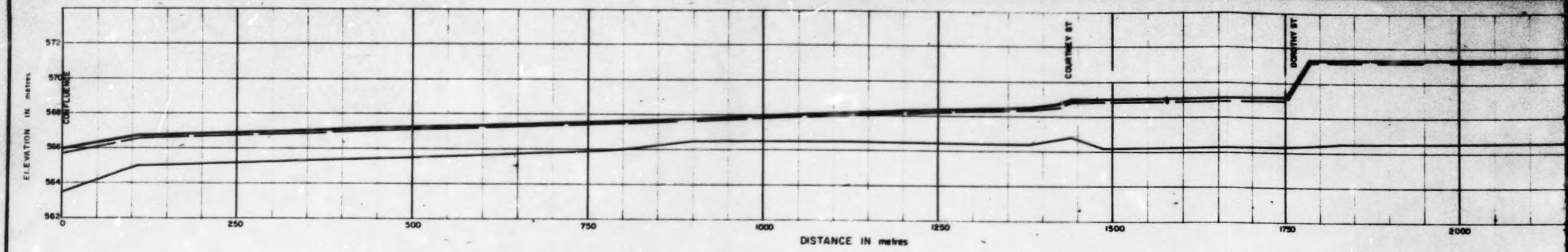
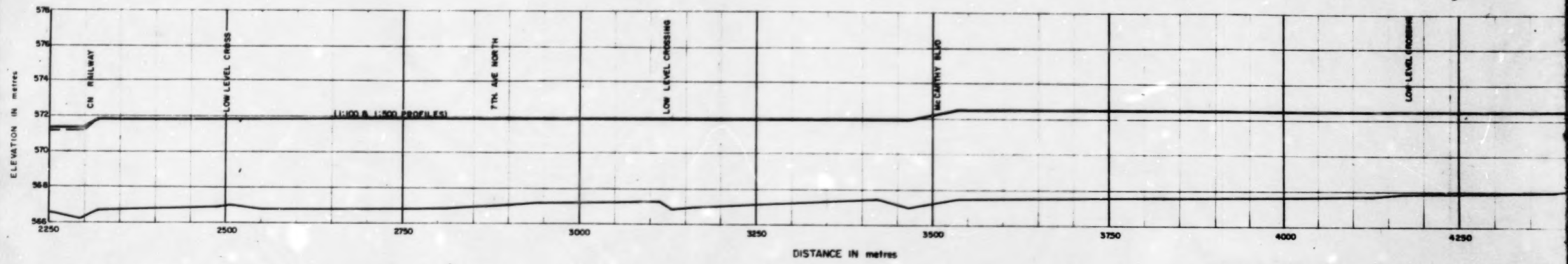
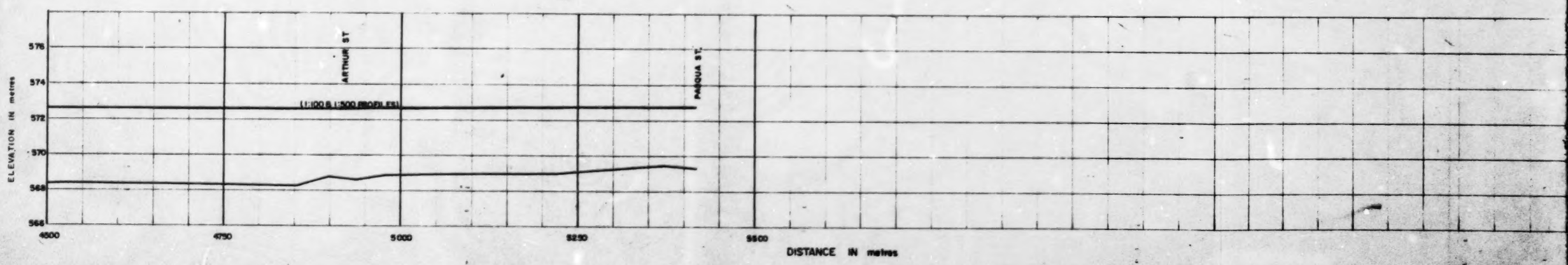
REGINA HYDRAULIC STUDY
SOUTH STORM CHANNEL
1:100 AND 1:500 YEAR
FLOOD PROFILES

Figure 9


ELEVATION IN metres
572
571
570
569
568
567
566
0
250
500
750
1000
1250
1500
1750
EMPRESS RD.
REGINA AVE
AIRPORT SERVICE ROAD
LEVIAN LINE (C.N.R)
WOOD CAR BRIDGE
PASQUA STREET
DISTANCE IN metres
573
HILL AVENUE
QUEEN STREET
LAKEVIEW AVENUE
25th AVENUE
PARLIAMENT AVENUE
1750
2000
2250
2500
2750
3000
3250
3500
RAE ST OUTLET
3500
3750
4000
4250
LEGEND
1:500 YEAR FLOOD PROFILE
1:100 YEAR FLOOD PROFILE
CHANNEL INVERT
Saskatchewan Environment
Hydrology Branch
Drn GVJ
Ck'd
Date JULY 198
Plan No. DS-4(25)
REGINA HYDRAULIC STUDY
SOUTH STORM CHANNEL
1:100 AND 1:500 YEAR
FLOOD PROFILES
Figure
9





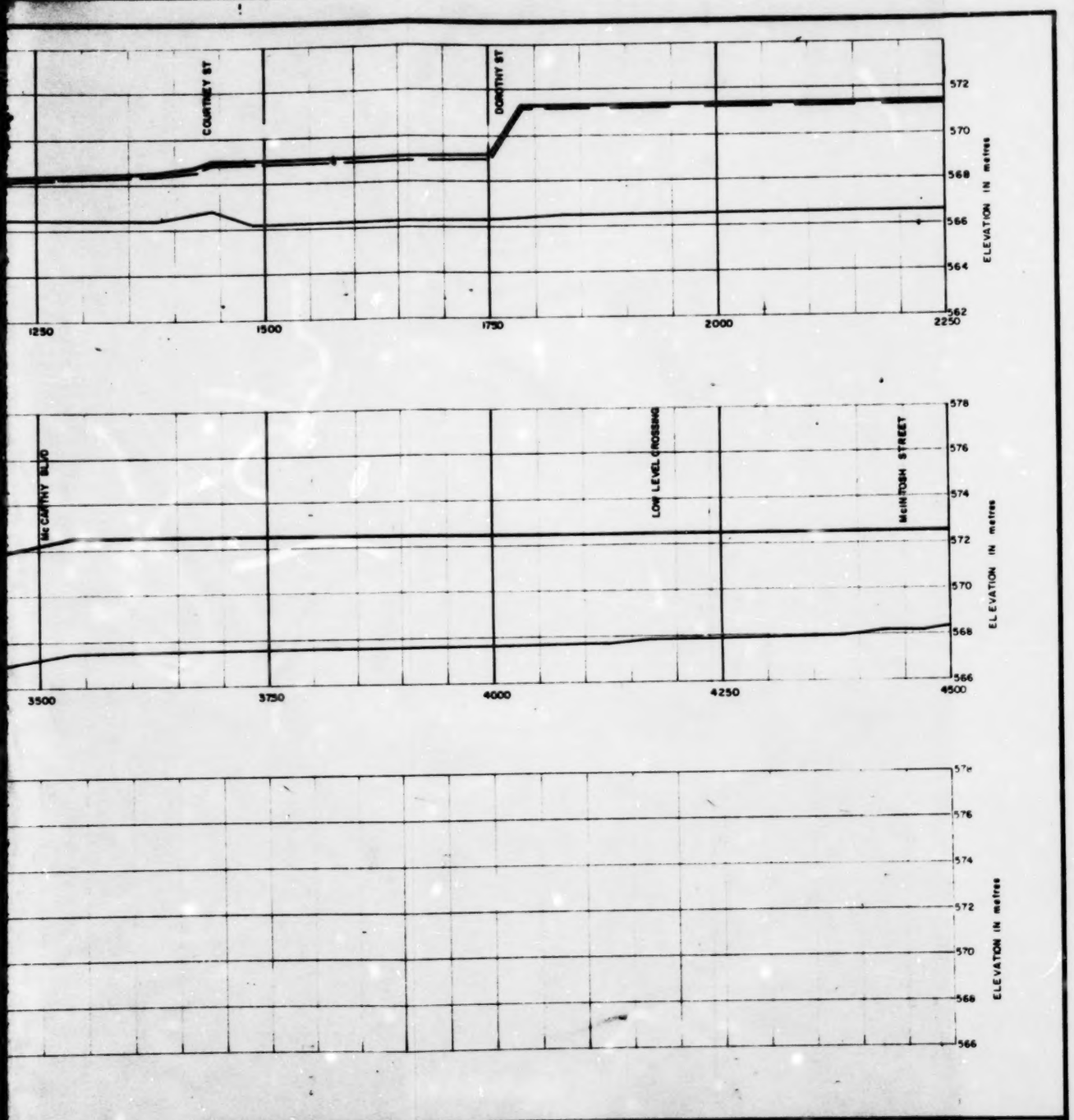


LEGEND
- 1:500 YEAR FLOOD PROFILE
- 1:100 YEAR FLOOD PROFILE
- CHANNEL INVERT

Saskatchewan Environment
Hydrology Branch

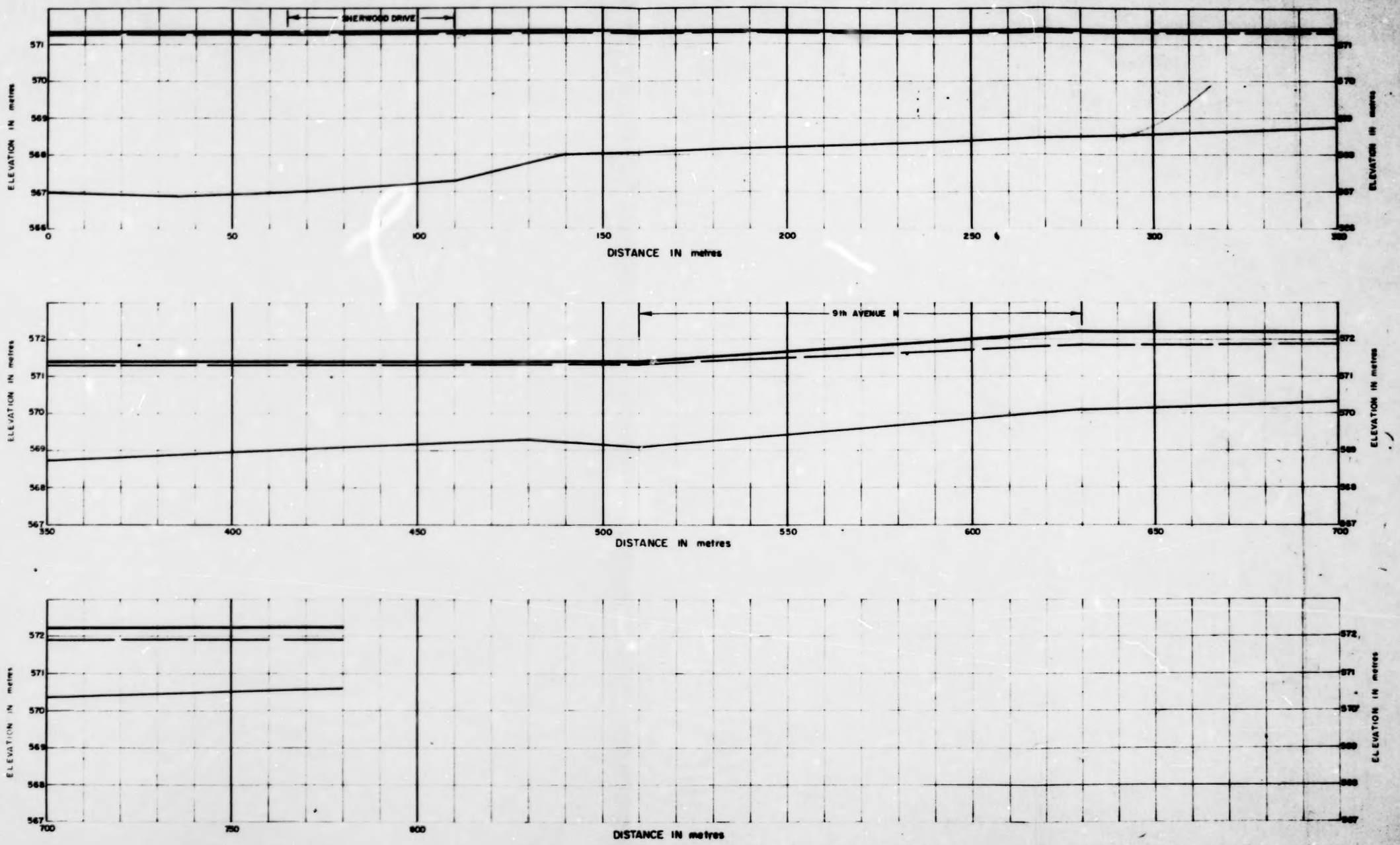
Drn GVJ | Date JULY 1981
Chkd | Plan No 80-4(5)-7

REGINA STORM
NORTH STORM
1:[illegible] AND 1:[illegible]
FLOOD PRO[illegible]



AR FLOOD PROFILE
AR FLOOD PROFILE
INVERT

Saskatchewan Environment Hydrology Branch	REGINA HYDRAULIC STUDY NORTH STORM CHANNEL 1:100 AND 1:500 YEAR FLOOD PROFILES	Figure 10
Drn GW Chk	Date JULY 1981 File No 83-4[illegible]	

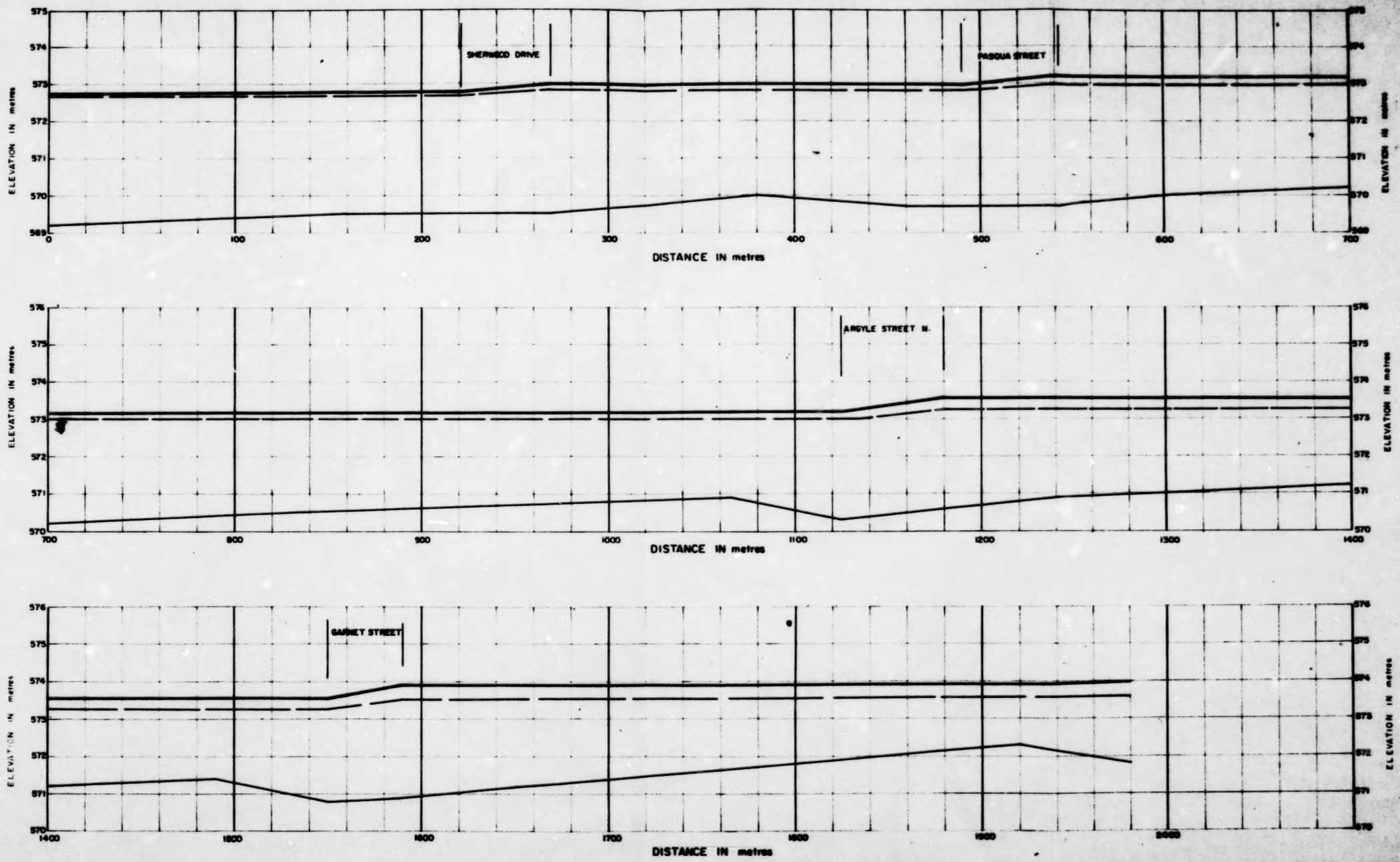


Saskatchewan Environment
Hydrology Branch

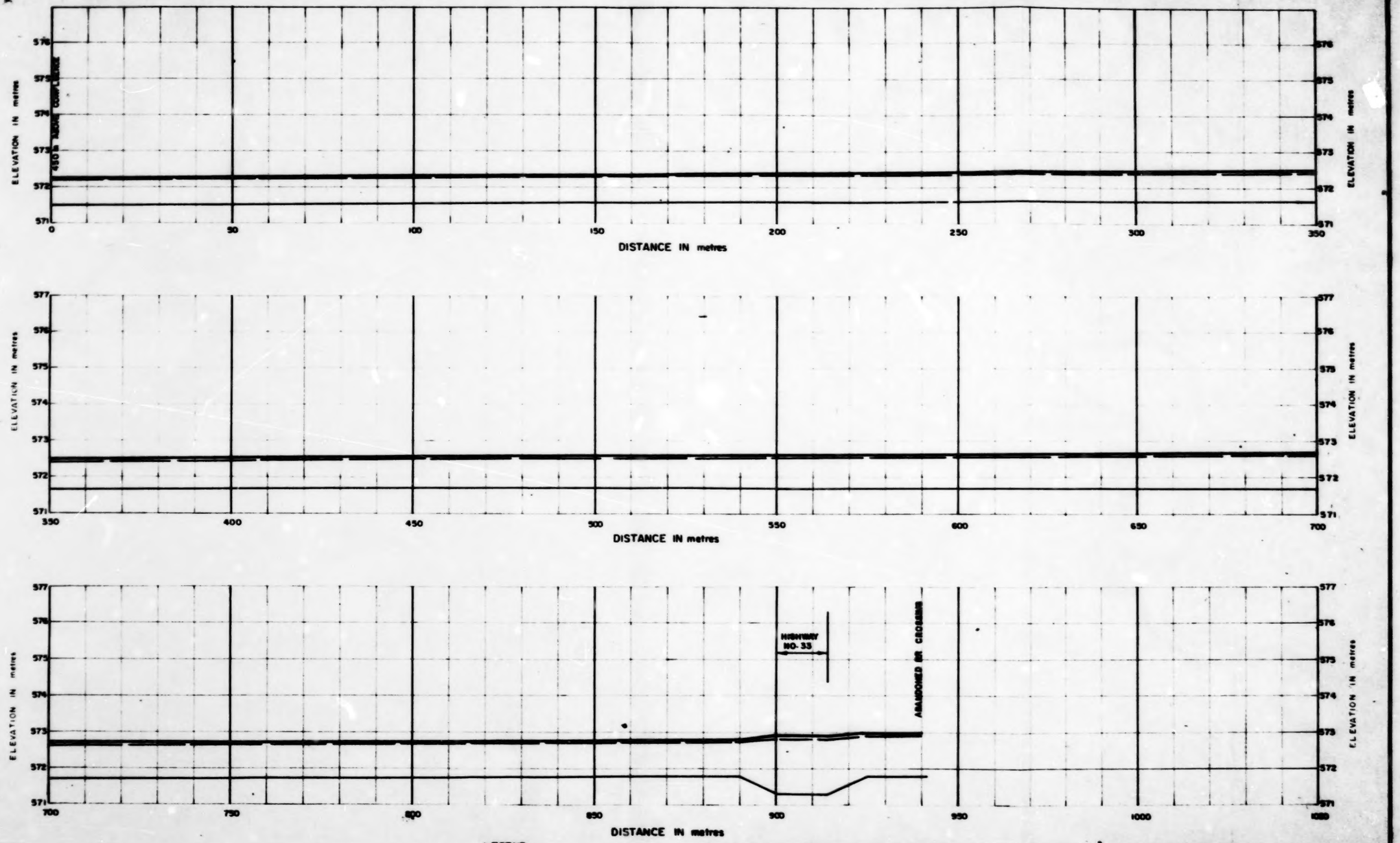
Drn GVJ	Date JULY 1981
Ch'd	Plan No. BS-4(23)

REGINA HYDRAULIC STUDY
NORTHWEST BRANCH OF NORTH STORM CHANNEL
1:100 AND 1:500 YEAR FLOOD PROFILES

Figure 11



Saskatchewan Environment Hydrology Branch		REGINA HYDRAULIC STUDY NORTH BRANCH OF NORTH STORM CHANNEL 1:100 AND 1:500 YEAR FLOOD PROFILES
Dwn BVJ	Date JULY 1981	Figure 12
Ch'd	Plan No. DS-4128)	



Saskatchewan Environment Hydrology Branch		REGINA HYDRAULIC STUDY CHUKA CREEK 1:100 AND 1:500 YEAR FLOOD PROFILES
Drn G.V.J	Date JULY 1981	Figure 13
Ch'd	Plan No. 05-4(29)	

APPENDIX I

MANNING'S ROUGHNESS COEFFICIENTS

Wascana Creek - Sewage Lagoons to Albert Street

Manning's 'n'				Manning's 'n'		
Secno	Channel	Overbanks		Secno	Channel	Overbanks
0	0.035	0.050		12608	0.030	0.050
660	0.035	0.050		12610	0.030	0.050
1180	0.035	0.050		12620	0.030	0.050
1755	0.035	0.050		12621	0.030	0.050
2265	0.035	0.050		12623	0.030	0.050
2755	0.035	0.050		12633	0.030	0.050
3075	0.035	0.050		12636	0.030	0.050
3088	0.035	0.050		12666	0.030	0.050
3090	0.035	0.050		13006	0.030	0.050
3100	0.035	0.050		13236	0.030	0.050
3102	0.035	0.050		13244	0.030	0.050
3115	0.030	0.050		13246	0.030	0.050
3395	0.025	0.050		13336	0.030	0.050
3855	0.025	0.050		13424	0.030	0.050
4375	0.025	0.050		13426	0.030	0.050
5060	0.025	0.050		13439	0.030	0.050
5415	0.025	0.050		13441	0.030	0.050
5715	0.025	0.050		13443	0.030	0.050
6135	0.025	0.050		13456	0.030	0.050
6615	0.025	0.050		13458	0.030	0.050
7010	0.025	0.050		13465	0.035	0.050
7310	0.025	0.050		13545	0.035	0.050
7325	0.025	0.050		13615	0.035	0.050
7328	0.025	0.050		13745	0.035	0.050
7358	0.025	0.050		14035	0.035	0.050
7818	0.025	0.050		14375	0.035	0.050
8083	0.025	0.050		14635	0.035	0.050
8113	0.030	0.050		14659	0.035	0.050
8121	0.030	0.050		14661	0.035	0.050
8151	0.030	0.050		14672	0.035	0.050
8891	0.030	0.050		14674	0.035	0.050
9351	0.030	0.050		14702	0.035	0.050
10031	0.030	0.050		14982	0.035	0.050
10047	0.030	0.050		15282	0.035	0.050
10647	0.030	0.050		15562	0.035	0.050
11220	0.030	0.050		15602	0.045	0.075
11540	0.030	0.050		15604	0.045	0.075
11940	0.030	0.050		15612	0.045	0.075
12230	0.030	0.050		15614	0.045	0.075
12580	0.030	0.050		15654	0.045	0.075

Wascana Creek - Sewage Lagoons to Albert Street (cont.)

Manning's 'n'				Manning's 'n'		
Secno	Channel	Overbanks		Secno	Channel	Overbanks
15744	0.045	0.075		18087	0.030	0.050
14884	0.045	0.075		18357	0.030	0.050
15886	0.045	0.075		18385	0.030	0.050
15896	0.045	0.075		18387	0.030	0.050
15924	0.045	0.075		18405	0.030	0.050
16434	0.045	0.075		18407	0.030	0.050
16934	0.045	0.075		18413	0.025	0.050
17384	0.045	0.075		18493	0.025	0.050
17412	0.045	0.075		18613	0.025	0.050
17414	0.045	0.075		18733	0.025	0.050
17422	0.045	0.075		18863	0.025	0.050
17424	0.045	0.075		18958	0.025	0.050
17474	0.035	0.075		19098	0.025	0.050
17524	0.035	0.075		19100	0.025	0.050
17574	0.035	0.075		19225	0.025	0.050
17617	0.035	0.075		19295	0.025	0.050
17619	0.035	0.075		19415	0.025	0.050
17637	0.035	0.075		19545	0.025	0.050
17639	0.035	0.075		19625	0.025	0.050
17667	0.030	0.050				

Wascana Creek - Albert Street to Richardson

Cross-Section Number	Manning's "n"	
	Channel	Overbanks
All cross-sections	0.030	0.050

Pilot Butte Creek

Cross-Section Number	Manning's "n"	
	Channel	Overbanks
All cross-sections	0.050	0.050

South Storm Channel

Cross-Section Number	Manning's "n"	
	Channel	Overbanks
All cross-sections	0.035	0.042

North Storm Channel

Cross-Section Number	Manning's "n"	
	Channel	Overbanks
0 to 2295 (confluence to CNR crossing) 2320 to 5417 (CNR crossing to Pasqua Street)	0.050 0.035	0.050 0.042

North and Northwest Branches of the North Storm Channel

Cross-Section Number	Manning's "n"	
	Channel	Overbanks
All cross-sections	0.035	0.042

Chuka Creek

Cross-Section Number	Manning's "n"	
	Channel	Overbanks
All cross-sections	0.090	0.090